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WILLIAM POLLOCK FRASER, 1867-1943

T. C. VANTERPOOL

(WITH 1 FIGURE)

On November 23, 1943, the ranks of Canadian botanists, and especially those of mycologists and plant pathologists, lost a prominent figure through the death of William Pollock Fraser, Emeritus Professor of Biology at the University of Saskatchewan. He had been suffering from heart trouble for some time, but was fortunately able to visit his herbarium until a few days before his death. He is survived by his widow, the former Alice McRae, who through their long years of comradeship frequently accompanied him on his collecting trips, and in later years was a constant helper in his herbarium.

Dr. Fraser was born on a farm in Pictou County, Nova Scotia. Through the untimely death of his father, the main burden of running the farm fell to him when still a young man. His early education was obtained at a typical country school, and it was not until his twenty-first year, when the family farm was sold, that he was able to attend High School, first at New Glasgow and later at Pictou Academy, from which he matriculated in 1896. Shortly afterwards he obtained a teacher's license in science and an agricultural diploma of Nova Scotia, and began his career as a school teacher. In 1899 he entered Dalhousie University where he pursued his studies for two years. Then followed a period in which he taught, first as Principal at Westville High School, and later as Instructor in Natural Science at Pictou Academy. He was already an inveterate plant collector and made good use of his own

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specimens for class demonstrations. To continue his training in botanical science he entered Cornell University in 1905, and in 1906 graduated with the B.A. degree. It was at Cornell that he came under the stimulating influence of Professor G. F. Atkinson, whom he held in very high esteem. The forays which he made among the glens at Ithaca in company with Professor Atkinson lent full play to his ingrained love of collecting and were, indeed, some of the most memorable of his life. On leaving Cornell he returned to his teaching position at Pictou Academy. About this time he began a correspondence and an exchange of specimens of rusts with Dr. J. C. Arthur at Purdue University, Indiana, which continued for many years.

He published his first scientific paper, *The Erysiphaceae of Nova Scotia*, in 1909. Then began a series of papers on cultures of heteroecious rusts. These mycological contributions at first exceeded his purely pathological ones, but the relationship was later reversed, due to circumstance of position and not wholly to any inherent preference for pathology. His early studies on the rusts culminated with the publication of a monograph on "The Rusts of Nova Scotia" in 1913. It was largely for these studies that he was granted the M.A. degree from Dalhousie University in 1910. "The Uredinales of the Prairie Provinces of Western Canada" appeared in 1925 with I. L. Connors as co-author. Several mycological papers on the complex host relations of the crown rust, *Puccinia coronata* Corda, concluded the series of contributions on heteroecious rusts. His final publications dealt with plant taxonomy.

In January 1912, he left his native province to become Lecturer in Biology at Macdonald College, McGill University. As his publications at this time show, he was concerning himself more with economic plant diseases. He spent part of the summer of 1915 studying diseases of the apple in the Annapolis Valley for the Nova Scotia Department of Agriculture.

Following the severe wheat rust epidemic on the Prairie Provinces in 1916, at the request of the Dominion Government he spent the two following summers in Western Canada surveying the rust situation and studying environmental and other causes which led to the 1916 outbreak. In 1919 he was appointed Officer-in-charge

of the new Dominion Laboratory of Plant Pathology established at Saskatoon in coöperation with the University of Saskatchewan. In 1925 he left the Government service to become full-time Professor of Biology, which position he held until his retirement from active teaching in 1937.

Dr. Fraser early realized that certain fundamental information on the cereal rust problem had to be ascertained before much progress in controlling these diseases could be made. Thus, during the first years at the Saskatoon Laboratory attention was given to such matters as field surveys, a study of the conditions that influence the spread and development of rust, native grass hosts, and the part, if any, they played in hibernation, the whole problem of the origin of outbreaks, and the extermination of the common barberry. These earlier projects were soon followed by studies on varietal resistance to stem rust and on the prevalence of physiologic races of *Puccinia graminis Tritici*. Dr. Fraser rapidly obtained an all-round picture of the diseases affecting cereal crops on the prairies and was soon able to initiate research on important diseases other than the rusts. The *Helminthosporium* diseases of wheat and barley, smut of slender wheat grass, *Fusarium* scab on wheat, and control of the cereal smuts, were among the earlier projects; and take-all of wheat (*Ophiobolus graminis*) was added later. He was proud of the fact that early steps had been taken which resulted in the eradication of the common barberry from the Canadian Prairies. In 1922, in the Report of the Dominion Botanist, he advocated that the planting and importation of the buckthorn (*Rhamnus cathartica* L.) should be forbidden. "The buckthorns that have already been planted should be eradicated," indicates that he believed the buckthorn should go the way of the barberry. Unfortunately the opportunity was allowed to pass. As head of the first laboratory of Plant Pathology in Western Canada, he may be said to have laid the foundation for plant disease work generally, and in particular for research work on the cereal rusts.

On his retirement from academic duties in 1937, the University of Saskatchewan bestowed on him an honorary LL.D. in recognition of his contributions to the solution of the cereal rust problem and of his outstanding work on the native flora of Saskatchewan, and also made him Emeritus Professor of Biology. He,

however, continued to have charge of the University phanerogamic herbarium which he planned to reorganize and extend. This proved to be a happy arrangement for the University and for him. He succeeded in building up an unsurpassed herbarium of wild plants of Saskatchewan. As a token of appreciation for this endeavour, the University authorities have designated this plant collection as "The W. P. Fraser Herbarium." Unfortunately he was prevented, partly by his failing health and partly because of the lack of trained assistants during the late depression and war years, from organizing the cryptogamic herbarium. The present fungus collection is made up largely of his own specimens and forms an excellent nucleus for a Mycological Herbarium of prairie forms.

Dr. Fraser was a Fellow of the American Association for the Advancement of Science, and an honorary member of the Canadian Phytopathological Society, of which he was Vice-President 1929-1931 and President 1931-1933. He was also a member of the Mycological Society of America and the American Phytopathological Society. He served for many years as a member of the Associate Committee on Field Crop Diseases of the National Research Council and the Dominion Department of Agriculture.

He was a man of sterling integrity, with a high ethical and moral sense which demanded strong qualities of will and character. His extreme modesty and reserved, unassuming manner—he hated pretense of any kind—tended to conceal much from his friends and associates. Yet he possessed a characteristically dry sense of humor which was often indulged in when least expected, thus making it all the more memorable. All who knew him well were won by the nobleness of his motives.

Being an untiring collector—his holidays were planned with collecting in mind—he always had a wealth of demonstration material, both dried and preserved, for his laboratory classes which he personally supervised, and made sure that the students' laboratory studies were from specimens examined both macroscopically and microscopically, and not from drawings in textbooks. As a teacher he was at his best with advanced and graduate students, who revered him as a man and for the straight-forward presentation of his material, which was based on a sound, first-hand knowledge of his subject. Upon students and associates alike his quiet enthu-

siasm and his diligent devotion to the task in hand made lasting impressions. He always presented a memorable picture when returning from collecting forays with his large vasculum over his shoulder and both hands full of specimens. One likes to remember him also among stacks of drying paper, wooden presses and drying boxes—bought and home-made—with rocks and scrap iron for weights. He had a rare knowledge of wild plants and of plant diseases in the field, supplemented by a keen ecological sense. Not only did taxonomists, mycologists and plant pathologists find his help invaluable, but also soils men in their studies of vegetation in relation to soil types.

Among specialists in his field he will be remembered chiefly for his studies on heteroecious rusts, as one of the pioneer mycologists and plant pathologists of Canada, and as an authority on the native flora of Saskatchewan. But, as a close associate has said, "his greatest influence will be through the effects of his own character on his students and colleagues."

UNIV. OF SASKATCHEWAN,
SASKATOON, SASKATCHEWAN.

STUDIES IN THE GASTEROMYCETES X. SEVEN NEW SPECIES OF TYLOSTOMA

W. H. LONG

(WITH 7 FIGURES)

The examination of several hundred specimens of *Tylostoma* has indicated that external characters are very characteristic and therefore important, although many of them heretofore have been only casually mentioned and some have never been noted at all. This has been especially true in describing species, where the characters usually stressed have been the spore markings and capillitium, the mouth characters, and in a general way the size of the plant.

Sporophore: The relative size of the plants is an important specific character, for instance, plants 1-3 cm. tall do not make plants 6-8 cm. tall and vice versa. Of course there may be an occasional giant or miniature specimen in a given collection, but such plants do not determine the normal size of the species.

Sporocarp: The tightness or looseness of the attachment of the sporocarp to the stipe apex is a fixed and important character. The sporocarp may be firmly or loosely attached to the stipe apex (FIG. 2), so that it easily becomes disjointed. The great majority of the species belong to the firmly attached type. I find this tightness or looseness a very important character and one that is constant for a given species.

Exoperidium: This consists of 2 distinct zones, a basal band or peridial sheath enclosing the base of the endoperidium (FIGS. 1, 2) and the remaining portion or the exoperidium proper. This *peridial sheath* is a tough layer of agglutinated hyphae and sand, firmly attached to the base of the endoperidium and differing in texture and composition from the exoperidium proper, which constitutes most of the exoperidium.

The exoperidium proper may occur in one of 3 different types

of structure; (1) a granular type consisting of hyphae and sand, (2) a semi-membranous structure, and (3) a permanently membranous exoperidium. All three types have an outer covering of sand loosely held together by mycelial threads when freshly emerged. The *granular exoperidium* has its inner layer composed of flocci which do not form a definite membrane, but produce an amorphous layer of hyphae attached rather firmly to the endoperidium and usually deciduous under weathering. This is the usual type of exoperidium found on most species of *Tylostoma* (FIG. 2). The *semimembranous* type has as its inner layer a very thin weak membrane, which, when dry, becomes friable, granular and usually early and completely deciduous, peeling off in flakes soon after emerging and leaving the endoperidium perfectly smooth (FIGS. 1, 7). The *membranous* type has as the inner layer of the exoperidium a permanent membrane (FIG. 4) and is completely deciduous, falling away in pieces and finally leaving the endoperidium perfectly smooth. This type is very rare.

Endoperidium: The color of the endoperidium varies for a given species. It may be white when fresh, or shades of drab, gray, and brown, many of these colors usually becoming lighter with age and weathering. As a rule each species retains its characteristic color for several months, although, of course, this color may be obscured by the fragments of the exoperidium persisting, or by adhering dirt. All endoperidia tend to whiten under prolonged weathering, and this is especially true of the gray and drab colored ones.

Mouth: Mouth characters present a definite basis for a primary dividing of the genus and may occur in three general types, (a) tubular, (b) fibrillose, and (c) indefinite. The first type may be a well marked tube, a short tube, or a very short or slightly projecting tubular rim. The fibrillose type may be divided into 2 subtypes, (a) those having a raised heavy fibrillose mat or border around the mouth opening and (b) those having a few fibrils around the opening even before weathering. This type of mouth is not uncommon in the arid regions of my territory. These fibrils often wear off under weathering, leaving the mouth indefinite and naked. The third type of mouth is neither tubular nor fibrillose, but simply consists of an indefinite lacerate aperture. Some plants

may have several mouths on the same sporocarp, usually of the short tubular type and often irregular in shape. I have seen but two plants with more than one mouth of the fibrillose type.

Stipe: The cortex or outer layer of the stipe or stem varies in color from white to shades of brown. This color as a rule deepens with age and weathering, in contrast to the color of the heads which tends to fade with age. Many stipes are white as they emerge from the soil, but may change to shades of brown in a short time. The normal color of such stipes when mature would then be classed as brown, while there are other species which have brown stipes from their first emergence. The cortex usually is not shed as claimed by some writers, but remains unless extreme weathering or handling causes it to break away. The stipes of all species of *Tylostoma* seen are white within and hollow, a characteristic of the genus.

The characters of the base of the stipe are very distinctive and can be divided into the following sections: (1) base radicating, not volvate or bulbous, (2) base bulbous with adhering hyphae and sand or even a solid woody bulb, (3) base bulbous and also radicating, (4) base volvate and not radicating, (5) base volvate and radicating, (6) bulbous and not radicating or a combination of 2 or more of these characters. Many of the basal characters are lost in collecting or in subsequent handling in the herbarium.

Volva: The volva is a term applied to certain species of *Tylostoma* which have a volvoid cup in which the stipe is seated. The genus does not have a universal veil, hence this is not a true volva. In addition several species have an inner or secondary volva consisting of the membranous lacerate remains of the upper part of the outer stipe cortex, which were torn loose from beneath the head on elongation and left as a collar around the base of the stipe inside the usual volva.

I am following Saccardo, Hollós, Coker and Couch and other prominent scientists in correctly spelling the generic name, *Tylostoma*. There is no legitimate Greek-English derivative, *Tulos-toma*, the word is plainly a mis-spelling and under the International Rules of Botanical Nomenclature, it is permissible to correct typographic or orthographic errors.

Tylostoma cretaceum sp. nov.

Sporocarp ovate, subglobose usque depresso-globose, 7–10 mm. alto, 10–20 mm. lato. *Exoperidio* semimembranaceo, toto secedenti. *Endoperidio* cretaceo albido. *Ore* parum fibrilloso. Stipite 3–10 cm. alto, tenui, 1–3 mm. crasso ad basim, pseudovolvatum, radicatum. *Sporis* subglobosis, 3.5–5.6 μ .

Sporophore consisting of sporocarp, stipe, volva and radicating base, originating 2–8 cm. below the surface of the soil. *Sporocarp* ovate, subglobose to depressed-globose, 7–12 mm. high by 10–20 mm. in diameter, firmly attached to the stem apex. *Exoperidium* semi-membranous, very thin, coated with sand, becoming friable and granular when dry, "mikado brown to russet" (Ridgway) when fresh, peeling off in flakes just as, or soon after emerging from the soil, usually before the mouth opens, drying to a thin granular layer of flocci and sand if the shedding is delayed, completely deciduous; *peridial sheath* non-deciduous, a narrow band 2–3 mm. wide with agglutinated hyphae and soil. *Endoperidium* chalky white when fresh (FIG. 1), often becoming dingy white in age, sometimes "tilleul buff," when exoperidium is slow in shedding, membranous, tough, smooth, often pitted. *Mouth* raised with a scanty fibrillose, granular, pitted peristome, circular, elliptic or irregular, with erumpent lacerate edges in age, stomatal fissures often extending to base of sporocarp under extreme weathering. *Stipe* slender, 3–4 cm. tall, usually attenuate downward, straight or curved, rarely uniform, 4–6 mm. thick at spore sac, 1–3 mm. thick at base, smooth, or sometimes minutely scurfy, becoming smooth in age, rarely striate, white. *Volva* double, outer layer formed from the mycelial pad at base of stipe, 6–10 mm. across by 4–6 mm. high, friable, margin incurved, rounded and even, composed of 2 layers (1) a thick gray, granular outer coat of agglutinated hyphae and sand, and (2) a cream-colored mycelial inner wall; surrounding the stipe inside the volva are the lacerate membranous fragments of the upper part of the stipe cortex 4–10 mm. high which were torn loose from beneath the spore sac on elongation. *Base of stipe* strongly radicating, roots 1–5 cm. long, 2–6 mm. thick where joined to volva, often branching, similar in context to volva, usually brittle when dry, hence easily broken in handling. *Gleba*, cinnamon brown to dark ferruginous. *Capillitium* colored, fulvous to brown, 3–7 μ thick, branched, flaccid, often flattened by collapsing then ribbon-like. Some breaking into short pieces, septa rare, not swollen. *Spores* subglobose to oval, mainly oval, some 1-guttulate, 4–4.5 μ in diameter for globose, and 3.5–4.2 \times 4.2–5.6 μ for the oval spores. *Epispore fulvous* to dark brown, smooth.

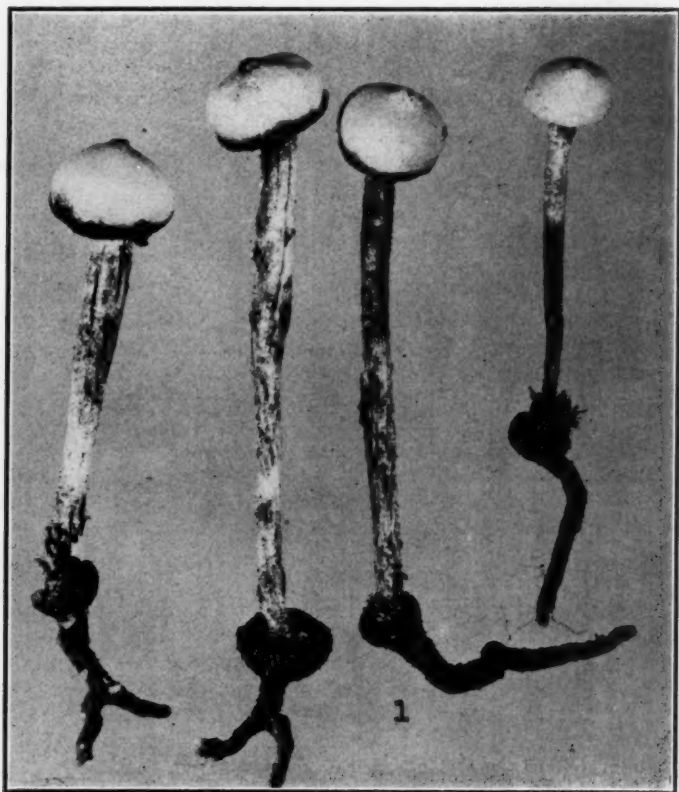


FIG. 1. *Tylostoma cretaceum*, fresh plants just emerged, $\times 1$.

HABITAT: Solitary in open, unshaded deep sandy soil and in gypsum flats.

DISTRIBUTION:

NEW MEXICO. SANDOVAL COUNTY, 3 miles south of the Bernalillo bridge on west side of Rio Grande River, elevation 5100 feet, *W. H. Long*, July 17, 1941—26 plants 9452; 2 miles south of Bernalillo on highway 85, *W. H. Long*, July 12, 1941—13 plants 9440, August 24, 1941—15 plants 9172. BERNALILLO COUNTY, on mesa near old golf links, elevation 5000 feet, *W. H. Long*, July

8, 1920—1 plant 5190; near old gun club grounds 8 miles south of Albuquerque, elevation 4900 feet, *W. H. Long*, May 30, 1917—4 plants 8993; west side of Rio Grande River in foothills near volcanoes, elevation 5200 feet, *W. H. Long*, June 23, 1917—1 plant 8874; 10 miles west of Albuquerque on lower mesa, elevation 5100 feet, *W. H. Long*, October 4, 1916—7 plants 5683; west side of Rio Grande River, 2 miles south of Alameda bridge, elevation 5000 feet, *W. H. Long*, October 11, 1918—69 plants 8387, May 7, 1939—83 plants 8396, March 17, 1940—2 plants 9150; *W. H. Long and David J. Stouffer*, December 8, 1940—104 plants 9197; *W. H. Long*, May 7, 1941—188 plants 9302 (Type), July 17, 1941—22 plants 9454, May 25, 1942—48 plants 10255; 4 miles north of Albuquerque on Highway 85, elevation 5000 feet, *W. H. Long*, May 31, 1941—198 plants 9338, June 10, 1941—53 plants 9352, June 25, 1941—123 plants 9364, October 7, 1941—40 plants 9820, May 7, 1942—45 plants 10245; east of Kirtland Field, army airport at Albuquerque, elevation 5000 feet, *W. H. Long*, November 27, 1941—17 plants 9909, November 28, 1941—106 plants 9915, January 19, 1942—1 plant 9979; southeast of Kirtland Field, elevation 4950 feet, *W. H. Long*, August 30, 1941—69 plants 9483, September 1, 1942—43 plants 9487. VALENCIA COUNTY, east of Rio Grande River, 4 miles below Belen bridge, elevation 4785 feet, *W. H. Long*, September 24, 1941—45 plants 9720, December 6, 1941—29 plants 9924. DONA ANA COUNTY, Jornada Experimental Range, elevation 4150 feet, *W. H. Long*, October 2, 1939—1 plant 9192; *W. H. Long and David J. Stouffer*, September 8, 1941—5 plants 9597. OTERO COUNTY, White Sands National Monument, in gypsum flats, elevation 4250 feet, *E. Ray Schaeffner*, August 30, 1941—3 plants 9687, 7 plants 9954, 4 plants 9955, 9 plants 9957; *W. H. Long*, April 22, 1942—24 plants 10110; making a total of 1405 plants collected to date.

The above distribution shows that *Tylostoma cretaceum* ranges from near Bernalillo, New Mexico, down the Rio Grande Valley to the Jornada Experimental Range some 28 miles east of Las Cruces, New Mexico, thence east to White Sands National Monument.

The plants growing west of the Rio Grande River were usually in open deep sand among *Parosela* and *Gutierrezia* vegetation in

the foothills near the river; on the east side of the river these plants were growing on small wind-formed sand dunes. Those collected below Belen were on sand-clay ridges in sage brush (*Artemisia*) areas, and showed a very pronounced peridial sheath around the base of the spore sac. The Jornada plants were growing in a sandy hard pan soil in open areas between the mesquite-sandhill dunes. The plants in the White Sands National Monument were in flats surrounded by gypsum dunes in open naked areas.

Many belated plants appearing in the fall of the year were flat-topped, with mouths not open or very slow to open. Such plants often had stipes uniform in diameter when fresh but tapering toward the base after weathering. All old weathered plants found always had strongly attenuate stipes.

The stipes are so firmly attached to the endoperidia that none were found which had become detached, even though the endoperidia might be so old and weathered that they had split open and the gleba of each had disappeared. Stipes of plants collected as they emerged became striate on drying from shrinkage, although mature plants in the field rarely showed any striae.

The fibrils of the peristome appear granular and pitted from the impress of the sandy exoperidium. This character is often not apparent to the naked eye but can easily be seen with a hand lens.

Tylostoma cretaceum has three outstanding characters, the chalky white endoperidium, the volva-like cup at the base of the stem and the large roots. The chalky white color may become a dingy white after long weathering, but the volva and the roots are always present even on the oldest plants. I have yet to find a single plant *in situ* that did not have these two latter characters. All mature plants found in the field had chalky white endoperidia when fresh, while only those collected before or while emerging and on which the exoperidia had dried had the "tilleul buff" color. One plant out of the 1405 collected was found which had two distinct, perfect mouths. The plants growing in the gypsum flats showed a few minor differences from those growing in sandy areas, the mouths for instance had fewer fibrils (in fact some did not have any, due possibly to loss in weathering), the mouth fissures were longer extending to the base of the spore sac in

many cases, the endoperidia were not so white and the stems shorter, often buried in the sand.

Tylostoma lysocephalum sp. nov.

Sporocarp globoso usque depresso-globoso, pulverulento-floccoso, 1.5-2.5 cm. alto, 2-3.5 cm. lato, facile ab apice stipitis secedenti. *Exoperidio* pulverulento-floccoso, nec toto secedenti. *Endoperidio* duro, membranaceo. *Stipite* 3-10 cm. alto, 8-12 mm. lato. *Sporis* subglobosis, 4-6 μ in diam. *Episporio* verrucoso, fulvo.

Sporophore originating 3-8 cm. below the surface of soil, consisting of sporocarp, stipe, volva, and bulbous rooting base, with usually only sporocarp appearing above the soil. *Sporocarp* globose to depressed-globose, large, 1.5-2.5 cm. high by 2-3.5 cm. wide, very easily separating from stem apex. *Exoperidium* a sand case, slowly deciduous. *Peridial sheath* a very thick heavy mass of agglutinated hyphae and sand, non-deciduous, 8-12 mm. wide, margin often with an irregular cupulate border, base of sporocarp very heavy so that the head usually comes to rest on the ground with mouth up, when separated from stem, thereby facilitating the dispersal of the spores. *Endoperidium* very tough, thick, membranous, rough with adhering sand and fragments of the exoperidium, warm buff to light buff, slowly weathering to dingy white. *Mouth* raised with a scanty fibrillose peristome, circular to elliptical, often with erumpent lacerate edges in age. *Collar* short, distinct from peridial sheath, 4-5 mm. distant from stem. *Stipe* stout, 3-10 cm. tall by 8-12 mm. thick, usually uniform, but sometimes slightly tapering downward, rough with coarse brown scales, which are slowly deciduous under weathering, usually with adhering sand-clay particles of soil, apex of stipe when disjointed from socket, concave to convex with a light buff smooth surface, also base of stipe often separating from enclosing bulb leaving a smooth slightly swollen end. *Volva* inconspicuous, often filled with soil, enclosed by a ball of hyphae and sand; *base of stipe* bulbous and radicating; *bulb* large 8-15 mm. wide, composed of hyphae and soil; *roots* short, stout and solitary. *Gleba* cinnamon-rufous. *Capillitium* hyaline, thinner than spores, 3-4.5 μ thick, walls thick, lumen closed except here and there a narrow slit, septa swollen, transverse to slightly oblique. *Spores* subglobose, 4-6 μ , usual size 5.6 μ . *Epispore* verrucose, fulvous.

HABITAT: Solitary or gregarious in groups of 3-6 individuals, on mesquite-sand dunes, under the mesquite brush in partial shade, or in partial shade of other desert shrubs.

DISTRIBUTION: New Mexico. DONA ANA COUNTY, 6 miles

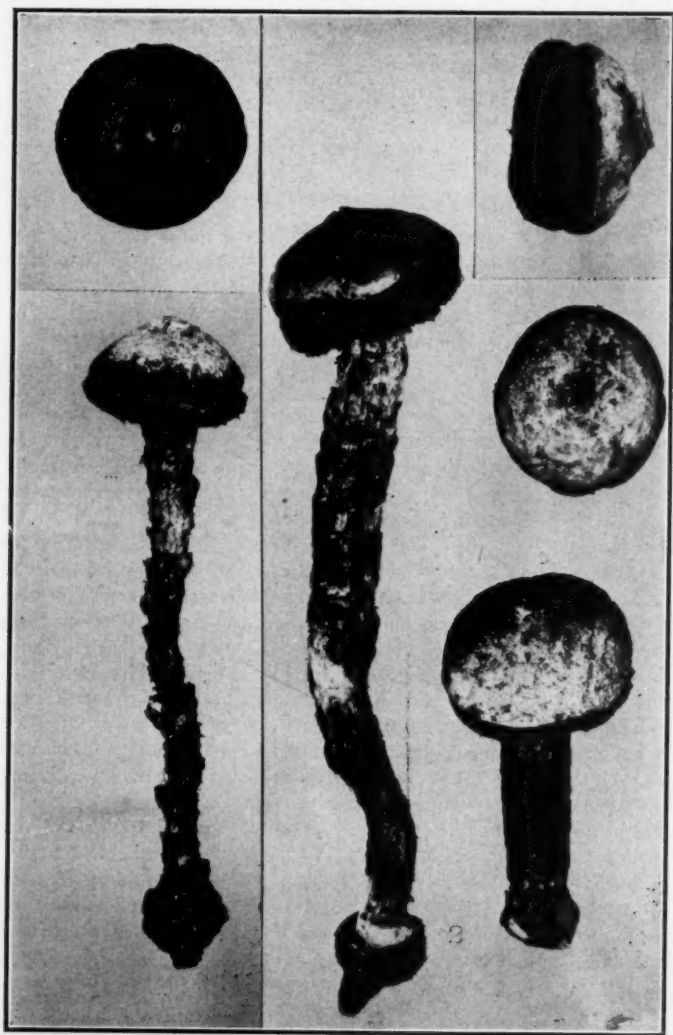


FIG. 2. *Tylostoma lysocephalum*, $\times 1$.

from Mesilla Park in Tortugas Mts., elevation, 4600 feet, *Ivan H. Crowell*, April 1, 1937—1 plant 8158 (Crowell no. 2458); Jornada Experimental Range, elevation 4150 feet, *W. H. Long, Ivan H. Crowell and Victor O. Sandberg*, May 2, 1937—9 plants 8178; east of San Augustine Pass on Highway 70, elevation 5500 feet, *W. H. Long and David J. Stouffer*, September 7, 1941—1 plant 9583. LINCOLN COUNTY, 8 miles south of Oscuro, elevation 5000 feet, *W. H. Long and David J. Stouffer*, April 18, 1941—1 plant 10081, *David J. Stouffer*, April 18, 1942—47 plants 10086; Pinos Mts. north of Cedarvale, elevation 7000 feet, *David J. Stouffer*, July 12, 1941—6 plants 9393; 20 miles N.W. of Corona, elevation 6500 feet, *David J. Stouffer*, July 23, 1941—1 plant 9551. LUNA COUNTY, 10 miles west of Deming on Highway 70, elevation 4300 feet, *W. H. Long and David J. Stouffer*, September 9, 1941—50 plants 9615, September 12, 1941—113 plants 9639 (Type), September 13, 1941—50 plants 9658; *W. H. Long*, April 24, 1942—16 plants 10064.

This species is unique in the looseness with which its sporocarps are attached to the stipes, more of these being found loose on the ground than on the stipes. These sporocarps (heads) are also very heavy due to the large amount of soil that clings to the peridial sheath, especially on those sites where there is a large amount of clay in the soil. It is also an unusually large, coarse plant, unsightly from the dirt clinging to heads, stipes and stipe bases.

***Tylostoma opacum* sp. nov.**

Sporocarpio depresso-globoso 10–15 mm. alto, 12–20 lato. *Exoperidio* pulverulento floccoso, nec toto secedenti. *Ore* parum fibrilloso. *Stipite* 2–5 cm. alto, 4–6 crasso. *Sporis* subglobosis opacibus, 7–11 μ . *Episporio* crasso, reticulato, prominenti, verrucoso.

Sporocarp depressed-globose, 10–15 mm. high by 12–20 mm. broad. *Exoperidium* a thin floccose layer of hyphae and sand, Sayal brown to fawn color, wearing away very slowly, leaving traces of flocci as inherent patches on the endoperidium. *Peridial sheath* remaining permanently as a thin layer of hyphae and sand. *Endoperidium* membranous, white, leathery in texture, smooth, thin, rather tough, attached firmly to stem apex. *Mouth* slightly raised, surrounded by a scanty fibrillose zone, concolorous with the exoperidium, narrowly elliptical, often enlarging in age. *Stipe* 2–5 cm. high by 4–6 mm. thick at apex, even or tapering somewhat

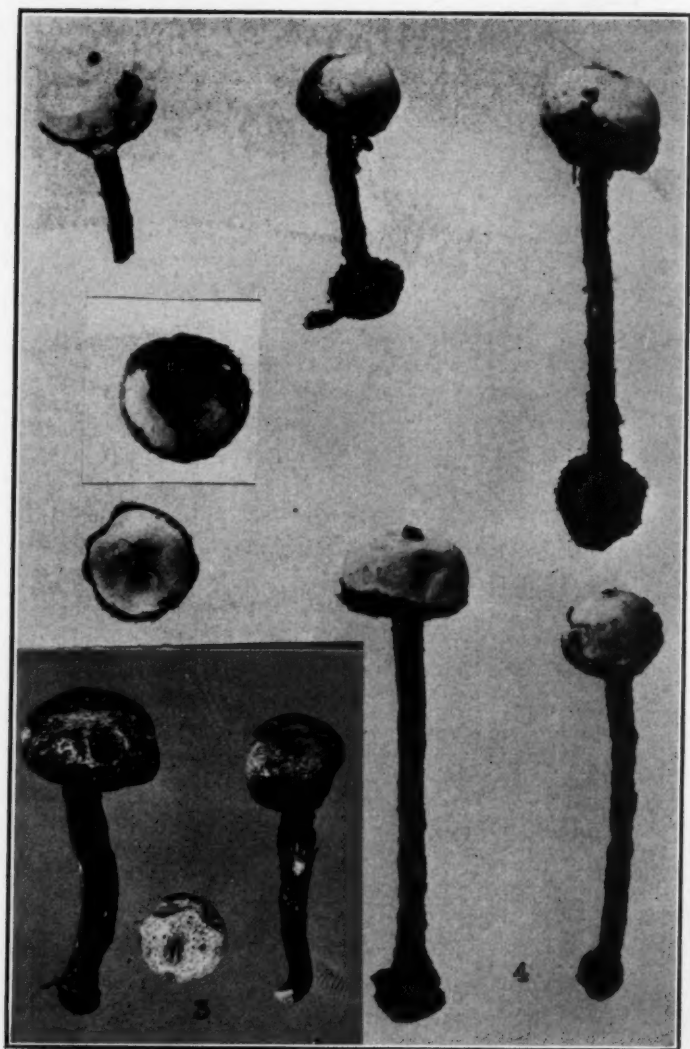


FIG. 3. *Tylostoma opacum*, $\times 1$; 4, *Tylostoma involucreatum*, $\times 1$.

toward base, cortex "Sudan brown," splitting into longitudinal fibres which tardily peel off leaving a white surface, white inside, woody, slightly bulbous at base; *bulb* hard, woody. *Gleba* brown-ochre to ferruginous; *capillitium* hyaline, sparingly branched, occasionally anastomosing, threads $4-11.5\ \mu$ thick in lactic acid, $8.8-12.7\ \mu$ thick in benzoazuren mount, usual size $4-5\ \mu$, some parts of unequal thickness in same thread, walls thick, unpitted, lumen in lactic acid very slight, represented only by a slit here and there, threads rounded and slightly swollen at the septa. *Spores* subglobose, opaque in water mount, $7-11.2\ \mu$ in diameter, usual size $8.4\ \mu$ including verrucae; *epispore* chestnut brown, walls up to $2.5\ \mu$ thick; reticulate with a distinct halo, covered with coarse, hyaline, finger-like processes which are up to $1.7\ \mu$ tall by $2.5\ \mu$ thick at base in lactic acid, $4.4\ \mu$ tall in benzoazuren, often deciduous, especially in a lactic acid mount under pressure on the cover glass, leaving the main spore center naked, smooth, subglobose to oval, $4.2-5.2\ \mu$ in diameter.

HABITAT: Solitary in heavy adobe soil in open, unshaded areas.

DISTRIBUTION: ARIZONA. PIMA COUNTY, 8 miles from Tucson on road to Sabino Canyon, elevation 2400 feet, *W. H. Long*, September 28, 1939—1 plant 8390. NEW MEXICO. DONA ANA COUNTY, Jornada Experimental Range, about 28 miles west of Las Cruces, elevation 4150 feet, *W. H. Long*, November 12, 1938—6 plants 8286 (Type).

This species is characterized by the very large opaque spores, the strong halo, the reticulate warty surface of the epispore, and the deciduous warts. The type collection was found about 1 mile from the mesquite-sandhill revegetative plat on the Jornada Experimental Range near the road to this area. The Arizona plant was found in an open area in mesquite-catchlaw flats (*Prosopis-Acacia*) in a sand-adobe-gravel soil with limestone subsoil. This species seems to be scarce as indicated by the few specimens found. During 1939 and 1941, the original areas were revisited and a careful search was made, but no additional specimens were found.

Only one other species of *Tylostoma*, *T. macrosporum* Cunningham, is known to me with such large spores. However, this species has a tubular mouth, while *T. opacum* has a fibrillose peristome.

Tylostoma involuocratum sp. nov.

Sporocarp globoso usque depresso-globoso, 5 cm. lato, 6-17 alto, albicanti. *Exoperidio* membranaceo, toto secedenti. *Endoperidio* toto levi, membranaceo. *Ore* mammoso, brevi. *Stipite* 4-9 cm. alto, 5-8 mm. crasso. *Sporis* subglobosis, 4.2-5 μ . *Episporio*, levi usque granuloso.

Sporophore originating 2-6 cm. below the surface of the soil, consisting of sporocarp, stem, and bulbous base. *Sporocarp* globose to depressed-globose, 1-2.5 cm. across by 6-12 mm. high, easily separating from stem. *Exoperidium* strongly and permanently membranous, outer surface a light buff to cartridge buff under sand layer, inner surface white, drying into a thin, very fragile involucre, slowly deciduous in flakes, leaving lacerate shreds of dried membrane on spore sac, often as a thin involucre around the top of the peridial sheath, thus producing a frilled appearance; *peridial sheath* a thick, tough band of agglutinated hyphae and sand, 5 to 7 mm. broad, often with a somewhat cup-shaped flaring upper margin. *Endoperidium* perfectly smooth, very tough, membranous, pale pinkish buff fading to pinkish white with age. *Mouth* tubular, short, often enlarged at base, giving the mouth a mammillate shape, small to medium size, usually circular. *Collar* thick, 3-6 mm. distant from stem. *Stipe* tall, 4-9 cm. high by 5-8 mm. thick, equal or slightly tapering downward, clay color to cinnamon buff, walls thick, woody, often nodose with short brownish scales which point upward, sometimes striate beneath the scales, usually dirty with adhering soil, expanding abruptly into a white, hard, woody disc enclosed by a bulb of hyphae and soil; *volva* none; *radicating base* none. *Gleba* in young stage just before elongating orange-yellow, when fully mature mikado brown; *capillitium* in water mount sub-hyaline, walls thick, no lumen in some threads, sparingly branched, 3-5.6 μ thick, septa rare not swollen. *Spores* subglobose to broadly oval, 4.2-5 μ in diameter; *epispor* chestnut color, walls apparently smooth to slightly granulose.

HABITAT: Gregarious in small groups of 2-4 individuals, in partial shade under desert shrubs and trees in sandy-clay soil.

DISTRIBUTION: ARIZONA, PIMA COUNTY, 8 miles from Tucson on road to Sabino Canyon, elevation 2400 feet, *W. H. Long* and *Victor O. Sandberg*, February 20, 1934—11 plants 7680, 1 plant 7610 and 1 plant 10014; *W. H. Long* and *David J. Stouffer*, September 10, 1941—4 plants 9624.

NEW MEXICO, BERNALILLO COUNTY, near Albuquerque, elevation 4950 feet, *W. H. Long*, August 30, 1941—5 plants 9482,

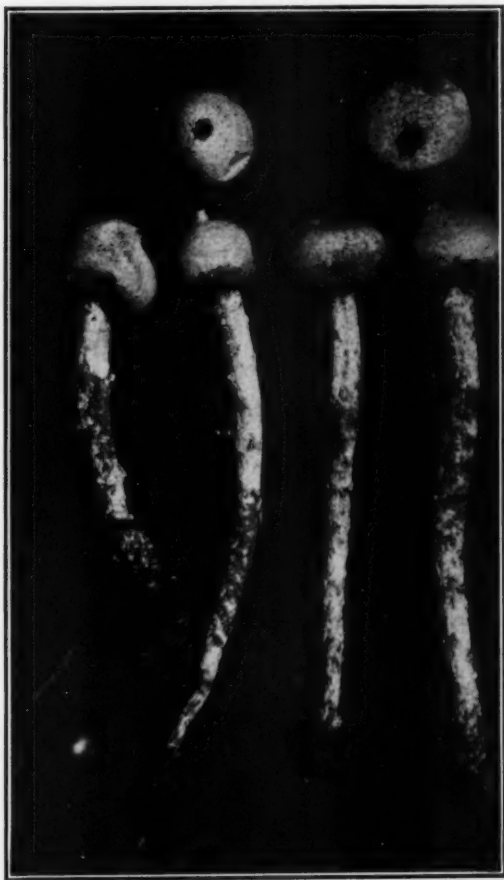


FIG. 5. *Tylostoma excentricum*, fresh plants, just emerged, $\times 1$.

November 27, 1941—17 plants 9910, January 19, 1942—18 plants 9976, January 27, 1942—10 plants 9981, April 4, 1942—2 plants 10050; 10 miles south of Albuquerque, elevation 4900 feet, *W. H. Long*, August 29, 1941—14 plants 9480, September 2, 1941—21 plants 9490. VALENCIA COUNTY, 4 miles south of Belen on State road 6, elevation 4800 feet, *W. H. Long*, September 18, 1941—3 plants 9684. DONA ANA COUNTY, Jornada Experimental Range,

elevation 4150 feet, *W. H. Long and David J. Stouffer*, September 7, 1941—1 plant 9587, September 8, 1941—7 plants 9606. LUNA COUNTY, 10 miles west of Deming on Highway 80, elevation 4300 feet, *W. H. Long and David J. Stouffer*, September 9, 1941—21 plants 9482, 5 plants 9616 and 9 plants 9617, September 11, 1941—31 plants 9644, September 13, 1941—42 plants 9650 (Type), and 4 plants 9819. LINCOLN COUNTY, 8 miles south of Oscuro, elevation 5000 feet, *David J. Stouffer*, February 17, 1942—25 plants 10018. Near Gallinas Forest Service Ranger Station, elevation 6800 feet, *W. H. Long*, September 6, 1941—1 plant 9676. OTERO COUNTY, White Sands National Monument in gypsum flats, elevation 4250, *W. H. Long and David J. Stouffer*, September 13, 1941—2 plants 9849.

The outstanding characters of this species are the permanently membranous exoperidium, which does not become granular on drying and the pale pinkish white endoperidium surrounded by the lacerate fragments of the membranous exoperidium which gives the sporocarp a frilled appearance. This frilling is a very marked feature and one not observed in other species of *Tylostoma* having tubular mouths, and is especially noticeable in the field when the plants are *in situ* and before they have lost this frilled look from handling by the breaking off of the thin fragile lacerate pieces of the exoperidium. Near Albuquerque this species is found on the mesa east of Kirtland Field Army Airport on *Yucca glauca* mounds, while in the arroyos it is found under *Fallugia paradoxa* bushes. In the Oscuro and Deming areas the plants grow on top of the mesquite-sand dunes in the shade of the mesquite trees (*Prosopis juliflora*).

***Tylostoma excentricum* sp. nov.**

Sporocarpio globoso, 6–15 mm. alto, 10–18 mm. lato, *exoperidio* pulverulento, ex parte secedenti. *Ore* regulari integro prominulo excentrico. *Endoperidio* flavido-avellaneo, aetate albicanti. *Stipite* attenuato, 3–9 cm. alto, apice 3–6 mm., basi 2–4 mm. crasso. *Sporis* globoso-ovatis, 4.5–5.6 μ . *Episporio* levi.

Sporophore originating 3–5 cm. below the surface of the soil, consisting of sporocarp, stipe, volva and bulbous radicating base. *Sporocarp* globose to slightly depressed-globose, 6–15 mm. tall by 10–18 mm. wide, not easily separating from apex of stem, sometimes one-sided or excentrically shaped. *Exoperidium* a thin sand

case, early deciduous; *peridial sheath* non-deciduous, consisting of hyphae and sand, tough, 3-6 mm. wide by 2-3 mm. thick, occasionally partially peeling off. *Endoperidium* tough, membranous, pale drab gray when fresh, fading to pale olive buff then to dingy white in age, smooth. *Mouth* tubular, tubes long, prominent, usually excentrically placed on the sporocarp, 1-2 mm. tall by 1-2 mm. wide, circular flaring at top. *Stipe* slender, fragile, very weak at top of bulb and often breaking off there, usually tapering downward, 3-9 cm. tall, 3-6 mm. thick at top by 2-4 mm. thick at bulbous base, white with thin fugaceous scales. *Volva* very inconspicuous, usually clasping the stem; *bulb* small, 5-8 mm. in diameter, surrounding the volva; *root* small, fibrous, single or often absent. *Gleba* cinnamon to raw sienna. *Capillitium* sub-hyaline, walls thick, threads thicker or same size as spores. *Spores* globose to oval, 1-guttulate, guttule large, some spores apiculate, 4.5-5.6 μ ; *epispore* appearing smooth, color smoky.

HABITAT: Solitary on low sand dunes in open unshaded spots, often thickly scattered over restricted areas.

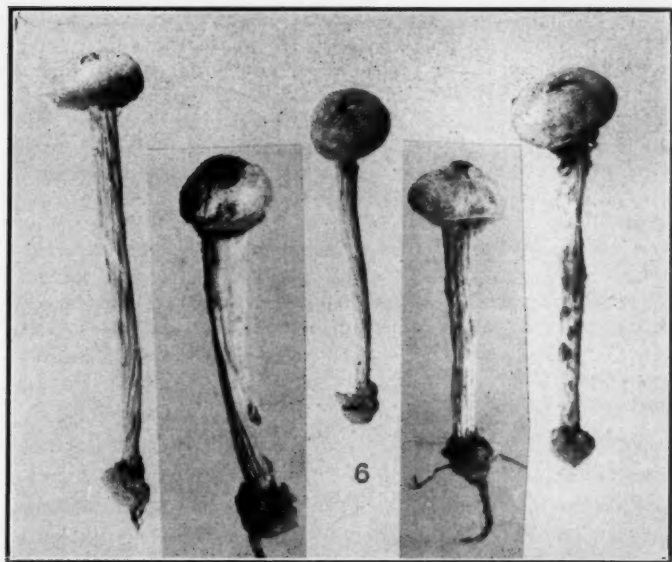
DISTRIBUTION: BERNALILLO COUNTY, 3.5 miles from Albuquerque on Highway 85 on south end of Sandia Plaza Addition, elevation 4950 feet, *W. H. Long*, May 30, 1941—140 plants 9395 (Type), June 5, 1941—10 plants 9347, February 8, 1943—1 plant 10405, February 12, 1943—1 plant 10420, June 20, 1943—4 plants 10368, 2 plants 10369; east of Sandia Vista Court on Highway 85, elevation 4950 feet; *W. H. Long*, June 20, 1940—1 plant 10418, June 20, 1941—83 plants 9360, August 23, 1941—15 plants 9468, October 16, 1941—22 plants 9822, February 1, 1942—10 plants 9997, May 24, 1942—20 plants 10254, January 22, 1943—21 plants 10421, February 15, 1943—2 plants 10440, July 1, 1943—10 plants 10371, August 7, 1943—10 plants 10386.

SANDOVAL COUNTY, 2 miles south of Bernalillo, west of Highway 85, elevation 4950 feet, *W. H. Long*, August 24, 1941—5 plants 9471.

***Tylostoma meristostoma* sp. nov.**

Sporocarpio subgloboso usque depresso-globoso, 5-10 mm. alto, 6-18 mm. lato. *Exoperidio* pulverulento-floccoso, nec toto secedenti, albicanti. *Endoperidio* papyraceo. *Ore* irregulare lacerato, indefinito, plano. *Stipite* tenui, 3-6 alto, 2-5 mm. crasso, albicanti. *Sporis* ovatis, subglobosis, 4-7 μ .

Sporophore originating 2-4 cm. below the surface of the soil, consisting of sporocarp, stipe, volva, and radicating base. *Sporo-*

FIG. 6. *Tylostoma meristostoma*, $\times 1$.

carp subglobose to depressed-globose, 5–10 mm. high by 6–18 mm. in diameter, sometimes concave beneath from pushing through the soil when emerging, firmly attached to stem apex. *Exoperidium* a sand case of flocci and soil, inner layer consisting of dingy white flocci, adhering very tightly to endoperidium, very slowly and imperfectly deciduous; *peridial sheath* a thin permanent band of hyphae and soil 3–5 mm. broad. *Endoperidium* dingy white, thin, papyraceous, fragile around mouth, rough from the adhering flocci of the exoperidium. *Mouth* indefinite, plane, at first a mere slit, soon becoming an irregular lacerate orifice (FIG. 6), whose edges may break off leaving a rounded aperture 3–4 mm. in diameter, naked with no signs of fibrils. *Collar* rather prominent, entire, restricted round top of stem. *Stipe* slender, 3–6 cm. tall by 2–5 mm. thick, even or a few tapering slightly toward base, white, smooth or striate from drying, seated in a small volva; *rooting* with one main root and often one or more side rootlets (FIG. 6). *Gleba* ferruginous; *capillitium* hyaline, threads short like those of a *Disciseda*, thin walled, sparingly branched, 4.2 to 7 μ thick, ends rounded, no septa seen. *Spores* oval, 4.2 \times 6 μ to 5.6 \times 7 μ , or subglobose 5.6–6 μ , usually 6 μ in diam.; *epispore* smooth, thin walled, chestnut color.

HABITAT: solitary in open, unshaded alkaline sand-clay soil.

DISTRIBUTION: NEW MEXICO, BERNALILLO COUNTY, 3.5 miles north of Albuquerque on Sandia Plaza Addition on Highway 85, elevation 5000 feet, *W. H. Long*, November 2, 1941—2 plants 10416, February 12, 1943—1 plant 10419, August 11–12, 1943—12 plants 10392 (Type).

This species belongs in Lloyd's group 7, having a mouth with an indefinite torn aperture and not surrounded by a fibrillose peristome. Lloyd placed 4 species in this group—*Tylostoma Rickii*, *T. australianum*, *T. Readeri* and *T. egramulosum*. *T. Rickii* has a dark reddish brown peridium and a stipe dark reddish brown with a fibrillose, sheath-like cortex, characters which would exclude my plant; while the other 3 species given by Lloyd have been listed by Cunningham as synonyms of *T. australianum*. I have examined the type of *T. australianum* and am sure that *T. meristostoma* is a different plant. *T. australianum* as described by Cunningham apparently does not belong to Lloyd's plant of this name nor to my species.

The type material of *Tylostoma meristostoma* was growing in an alkaline hard pan soil in a live prairie dog town (*Cynomys ludovicianus arizonensis*). Seven of the plants were collected August 11, 1943, three days after a heavy summer rain; all were fresh in various stages of emergence with the sandy exoperidia on sporocarps and stipes still soft, while 2 plants already had slit mouths. Five more plants were found August 12, 1943, some 50 feet from the first location, four having just emerged, while the 5th plant was older and evidently had emerged before the last rain. This plant was dry and had lost the outer sandy coat of the exoperidium, but not the inner flocci. Its mouth was an irregular round hole 4 mm. in diameter.

All the fresh plants were placed, as soon as collected, in wet soil for several days with their bases buried in the soil then put in direct sunlight and wet every 24 hours for several days. The stipes completed their elongation, but the sandy exoperidia remained unchanged and all of the plants developed the slit mouths after several days of drying.

I have collected and examined several thousand *Tylostoma* plants and was dubious that any species had a normally slit mouth as de-



FIG. 7. *Tylostoma macrocephalum*, $\times 1$.

scribed by Lloyd for his group 7. I have found any number of plants with irregular, lacerate mouths but a careful study of such plants showed that this mouth condition was due to age and weathering and therefore was not their normal condition when fresh. These lacerate mouths had either been fibrillose or tubular and had become so worn by weathering that these distinguishing mouth characters had disappeared. I was therefore much surprised to find plants with slit, lacerate mouths as a normal condition when fresh.

***Tylostoma macrocephalum* sp. nov.**

Sporocarp subglobose usque depresso-globoso, 8-15 mm. alto, 12-28 mm. lato, regulari, integro. *Exoperidium* semimembranaceo, toto secedenti. *Endoperidium* levi albicanti, membranaceo. *Ore* mammoso, 2-4 mm. in diam. *Stipite* 5-13 cm. alto, 5-12 mm. lato, lignoso. *Sporis* globosis, 4.2-5.6 μ . *Episporio* verruculoso.

Sporophore originating 4-8 cm. below the surface of the soil, consisting of sporocarp, volva and bulbous radicaing base, underside of sporocarp and stipe thinly covered with a clinging arachnoid mycelium containing soil particles which are easily brushed off.

Sporocarp subglobose to depressed-globose, 8-15 mm. high by 12-28 mm. in diameter, firmly attached to stipe apex. *Exoperidium* semi-membranous, thin, outer surface grayish white, inner cartridge buff, early and completely deciduous; *peridial sheath* a broad thin band of hyphae and soil, on some plants assuming a cup-like shape, the sides of the cup being the unshed membranous fragments of the exoperidium. *Endoperidium* smooth, dingy white, very tough, membranous. *Mouth* tubular, short, tough, medium to large size, 2-4 mm. in diameter, circular or broadly elliptical. *Stipe* 5-13 cm. tall by 5-12 mm. thick, white, stout, straight, even or slightly tapering toward base, woody, scaly, often becoming transversely rimulose with age after the scales have fallen. *Volva* surrounding the hard woody, globose base of stipe, small, friable, enclosed in a globose mass of hyphae and soil, often having an inner secondary volva of the lacerate fragments of the stipe which were torn loose from under the sporocarp on emerging. *Base of stipe* radicaing, roots central, stout, thick and short. *Gleba* cinnamon rufous to ferruginous. *Capillitium* hyaline, 5-5.6 μ thick, walls thick, lumen none or with very narrow slits here and there, sparingly branched, occasionally anastomosing, some threads unequal in thickness in same thread, no septa seen. *Spores* globose, rarely oval, 4.2-5.6 μ , usual size 5 μ , with one very large guttule, or

oil globule, nearly filling the interior of the spore; *epispore* verruculose, walls thick chestnut brown.

HABITAT: solitary or gregarious in small groups in alkaline sand-clay soil, and in open spots in gypsum flats on mounds of dead *Atriplex canescens*.

DISTRIBUTION: NEW MEXICO, LINCOLN COUNTY, near Corona, elevation 7100 feet. *W. H. Long and David J. Stouffer*, April 21, 1940—1 plant 9190; *David J. Stouffer*, June 17, 1941—11 plants 9392; 8 miles south of Oscuro, elevation 500 feet. *David J. Stouffer*, February 20, 1942—13 plants 10022. OTERO COUNTY, White Sands National Monument, elevation 4250 feet, in flats west of first gypsum dune, $\frac{1}{3}$ mile N.W. of Administration Building, *W. H. Long and David J. Stouffer*, September 13, 1941—3 plants 9648, 2 plants 9757, April 22, 1942—11 plants 10111; in an adjacent gypsum flat, 11 plants 10113 (Type). 20 miles west of Tularosa in white sands area (gypsum), elevation 5000 feet, *W. H. Long and David J. Stouffer*, September 14, 1941—13 plants 9685. SANDOVAL COUNTY, 5 miles west of San Ysidro on state highway 84, elevation 6200 feet, *W. H. Long*, July 9, 1941—11 plants 9386. BERNALILLO COUNTY, south of Kirtland Field airport, Albuquerque, N. M., elevation 5000 feet, *W. H. Long*, September 1, 1941—17 plants 9481, November 28, 1941—1 plant 9913.

The 2 small flats or valleys where the plants were found in the White Sands National Monument were entirely surrounded by gypsum dunes (hydrous calcium sulfate) which have no drainage outlets so that the soil is heavily impregnated with gypsum from rain water and from windblown particles of gypsum settling in the flats.

All specimens listed are deposited in the Long Herbarium at Albuquerque, New Mexico, unless otherwise stated.

ACKNOWLEDGMENTS

I am under many obligations to Mr. John A. Stevenson for loan of material and for important advice; to Dr. Fred J. Seaver for loan of material; to Mrs. Vera Miller for checking the glebal characters of *T. opacum*; to Dr. David H. Linder for advice on the

names; to Prof. Sultan Ahmad for valuable material from India; to the University of North Carolina for loan of material; to the National Parks Service for permission to investigate the fungus flora of the White Sands National Monument.

ALBUQUERQUE,
NEW MEXICO.

THE HORSE-HAIR FUNGI

FRED J. SEAVER

(WITH 1 FIGURE)

A peculiar fungus has recently come to the writer for determination and it was concluded that it belonged to the above named group. So far as known the horse-hair fungus or blight represents the mycelial stage of a *Marasmius*, based on material collected in Australia and described by Kalchbrenner as *Marasmius crinis-equi* (Grevillea 8: 153. 1879). Later Berkeley (Jour. Linn. Soc. 18: 383. 1883) changed the spelling of the specific name to "*equicrinis*." The original spelling, however, should be retained. There are several closely related species belonging to this category. The following description of the typical species is given by T. Petch (Ann. Royal Bot. Gard. Peradeniya 6: 43-44. 1915):

"The mycelium of this species is the common horse-hair blight of Ceylon. It consists of a smooth, tough, black cord, from one-tenth to one-eighth of a millimetre in diameter, which runs in all directions over bushes and trees, up to a height of 20 feet above the ground, attached to the living stems and leaves at intervals of one to four centimetres, or throwing out long free threads to adjacent branches. Its course is quite a random one. After proceeding along a branch for a short distance, it may leave it and attach itself to a leaf, and after crossing several leaves may return to its original branch. Or it may travel from a branch to a leaf via the leaf stalk, and may make a complete circuit of one surface of the leaf before proceeding further. In general, the whole of the mycelium is aerial; it is not connected with any mycelium on the ground, and does not ascend the tree from the ground level. It has been observed at the base of *Hevea* trees, where it grows on the outer dead bark, but this is an exceptional case, and it has not been known to climb up to the leaves from that position.

"When the leaves die they adhere to the mycelium until they

decay and disintegrate, and consequently there is produced a tangled mass of leaves and mycelium, with sometimes twigs also, suspended in the bush or tree. The mycelium, however, does not appear to be parasitic."

The American material sent for determination consists of the mycelial stage only, but agrees quite closely with the above description. The material was encountered by our soldiers during maneuvers near Evans, Louisiana. According to reports the strands which extended from branch to branch often contacted the



FIG. 1. A wisp of horse-hair fungus collected by Lt. W. P. Comstock, Jr. in Louisiana, and sent in for determination.

boys' faces as they plunged through the thickets and were thought to be spider webs. Finally the material photographed was sent in for determination. On request for further information the following note was enclosed:

"There was a considerable amount of horse-hair blight in scrub oak at about eye level in bivouac area S.W. Evans [Louisiana], Dec. 5, 1943. Found by 1st Lt. W. P. Comstock, Jr., used for sewing on buttons." The use made of these black mycelial strands by the soldiers is exceedingly interesting. Whether they are tough enough to make a satisfactory substitute for thread we are unable to say.

So far as the writer can learn only one previous collection has been reported in continental North America. This specimen is in

the Farlow Herbarium at Harvard University and was obtained by Brother Arsene, an amateur collector, and was found at Lafayette, Louisiana. So little is known of the fungus in America that it seems worth noting at this time.

THE NEW YORK BOTANICAL GARDEN.

A NEW SPECIES OF METARRHIZIUM ACTIVE IN DECOMPOSING CELLULOSE

SETH POPE

(WITH 2 FIGURES)

INTRODUCTION

A fungus, isolated from deteriorated baled cotton stored in Washington, D. C., and tentatively assigned by Dr. Charles Thom to the genus *Metarrhizium*, was reported by Greathouse, Klemme, and Barker (4) to have shown extraordinary activity in decomposing cotton fabric in certain pure-culture tests. This fungus has since been used in the Division of Cotton and Other Fiber Crops and Diseases, and in other laboratories, in connection with the evaluation of mildewproofing agents or rot resistance of fabrics (5). It is easily handled in culture, sporulates freely, and has remained stable in its cultural characteristics and cellulose-decomposing activity for the past 3 years. Preliminary studies have indicated that this fungus is not identical with any known species of *Metarrhizium*, so it appears desirable to describe it as new.

LITERATURE REVIEW

Sorokin (10) in 1879 transferred Metschnikoff's *Entomophthora anisoplia* (6) to the genus *Metarrhizium*, making the new combination *M. Anisopliae* (Metsch.) Sorokin. Rorer (9), Stevenson (12), and Petch (8) give extensive bibliographies of this fungus.

Vuillemin¹ (15) described *Penicillium Anisopliae* as forming a large thallus of which the filaments were compressed and branched, forming small hummocks, often confluent and disappearing under the mass of conidia they produced. Sterigmata and the branches,

¹ Since Sorokin's papers were not available, the description of *M. Anisopliae* was taken from Vuillemin (15).

either isolated, in pairs, or in verticils, arose below the septa of the upper part of this stalk. The conidia were formed in basipetal succession at the expense of the sterigmata, and were united by a disjuncter which was a modification of the membrane, flattened and compressed by the pressure of the growth of new conidia. The resulting columns of conidia composed of conidial chains often reached a length of 800μ or more. The conidia were olive green in color, and cylindrical, with rounded ends. Chlamydospores were found in cultures grown on carrots.

The conidial measurements of *M. Anisopliae* when grown on various media have been reported to be $4.8 \times 1.6\mu$ (14). Other workers report measurements ranging from $4.5 \times 2\mu$ to $7-15 \times 2.5-3.5\mu$ (1, 8, 9, 15).

CHARACTERISTICS OF THE FUNGUS

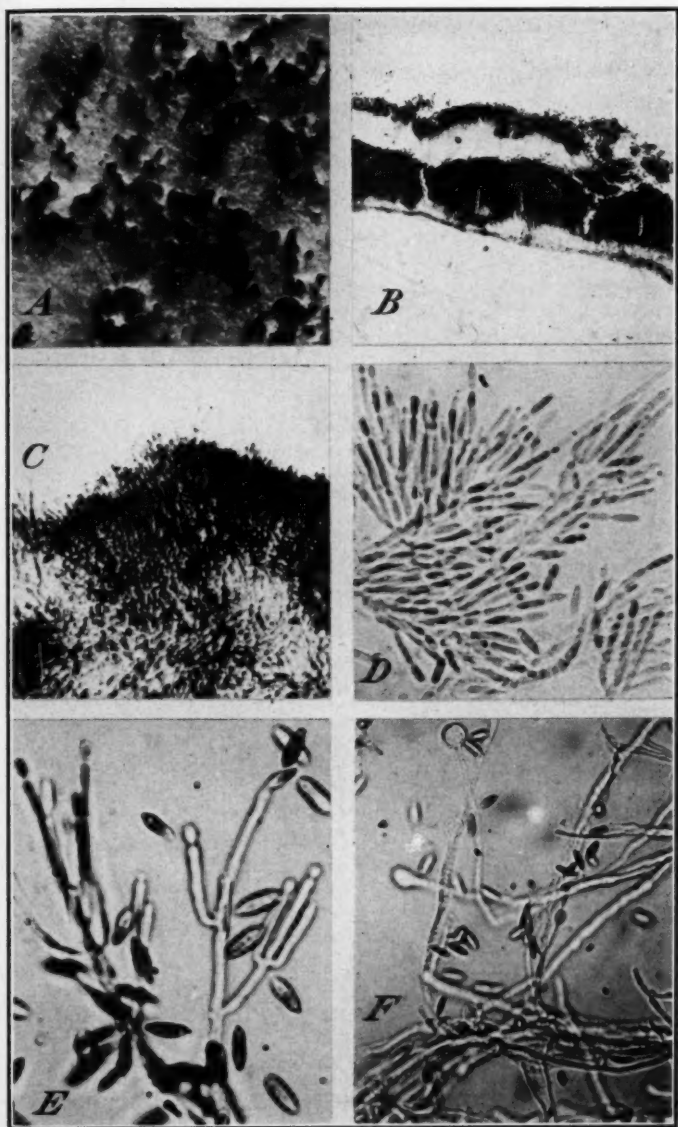
The fungus, growing on filter paper, at first produces a sparse white mycelium in which small tufts of conidiophores arise. These conidiophores are compact, forming a palisade layer in each tuft (FIG. 1, B and C). The moist conidial masses produced on these tufts often coalesce, forming masses 0.5-2 mm. in diameter (FIG. 1, A). The conidia are dusky olive green to olivaceous black,² cylindrical, with rounded ends, $6-9.6, 1.5-3.9\mu$, formed on sterigmata in basipetal succession and united by disjunctors, but breaking away in the conidial mass soon after formation.

The conidiophores are penicillately branched $50-85\mu$ long, erect, and septate. The ultimate branches are verticillate, composed of 1 to 3 sterigmata each, 10 to 22μ long (FIG. 1, D and E).

Chlamydospores are produced in bulbous terminal portions of the hyphae found near the substrate and embedded in the mycelium (FIG. 1, F). The mature chlamydospore is nearly round, smooth with a small tapered papilla at one side, buckthorn brown, and 7.4 to 9μ in diameter.

² Ridgeway, R., Color Standards and Nomenclature, 1912, pl. XLI and XLVI.

FIG. 1. *M. glutinosum*. A, filter paper culture, $\times 8.5$; B, section of filter paper culture, $\times 100$; C, palisade arrangement of conidiophores, $\times 200$; D, conidiophores, $\times 530$; E, conidiophores, $\times 900$; F, chlamydospore formation, $\times 530$.



The above characteristics indicate that the fungus belongs in the genus *Metarrhizium*, and it is described as new.

***Metarrhizium glutinosum* sp. nov.**

Mycelial mat, grown on filter paper (in contact with an inorganic nutrient solution³), pure white with dusky olive green to olivaceous black conidial masses on tufts of mycelium; conidiophores up to 75 μ long, smooth, erect, septate, penicillately branched above, forming a palisade layer in tufts on which olivaceous black glutinous masses of conidia are produced; conidia catenate, borne directly on fingerlike sterigmata, conidial chains distinguishable in masses only in early stages of formation, conidia elongate-ovoid, smooth, dusky olive green to olivaceous black, $6-9.6 \times 1.5-3.9 \mu$. A type specimen has been placed in the Mycological Collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering under the identification number 1334.2.

Sterigmatibus clavatis 10-22 μ longis; conidiis cylindraceutis utrimque rotundatis $6-9.6 \times 1.5-3.9 \mu$ glabris olivaceonigris, in massa obscure olivaceis usque olivaceonigris, glutinosis; catenis conidiorum solum in statu juniore evidentibus.

In order to eliminate any possible confusion between *M. glutinosum* and *Gliocladium fimbriatum* Gilman and Abbott, a few of the differences are pointed out.

The conidia of *G. fimbriatum* are borne in moist heads which may coalesce, but no palisade or hymenium-like arrangement of the conidiophores is evident. Moreover, these conidia are produced on flask-shaped phialides which are quite different in shape from the sterigmata of *Metarrhizium* (FIG. 2, A).

The branching of the conidiophores and the structure of the sterigmata are quite similar in *M. glutinosum* and *M. Anisopliae* (FIG. 2, C, E, and D). The principal difference between these two species is found in the conidial masses; those of the former are moist, and the latter dry.

Further comparisons are presented in table 1.

³ NH_4NO_3 , 1 gm.; $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 0.7 gm.; K_2HPO_4 , 0.69 gm.; KH_2PO_4 , 0.69 gm.; and dist. H_2O —1000 cc.

FIG. 2. A, B, *Gliocladium fimbriatum* after Gilman and Abbott; C, E, *M. Anisopliae*, after Speare; F, *M. Anisopliae*, palisade arrangement of conidiophores after Speare; D, *M. glutinosum*; G, *M. glutinosum* palisade arrangement of conidiophores.

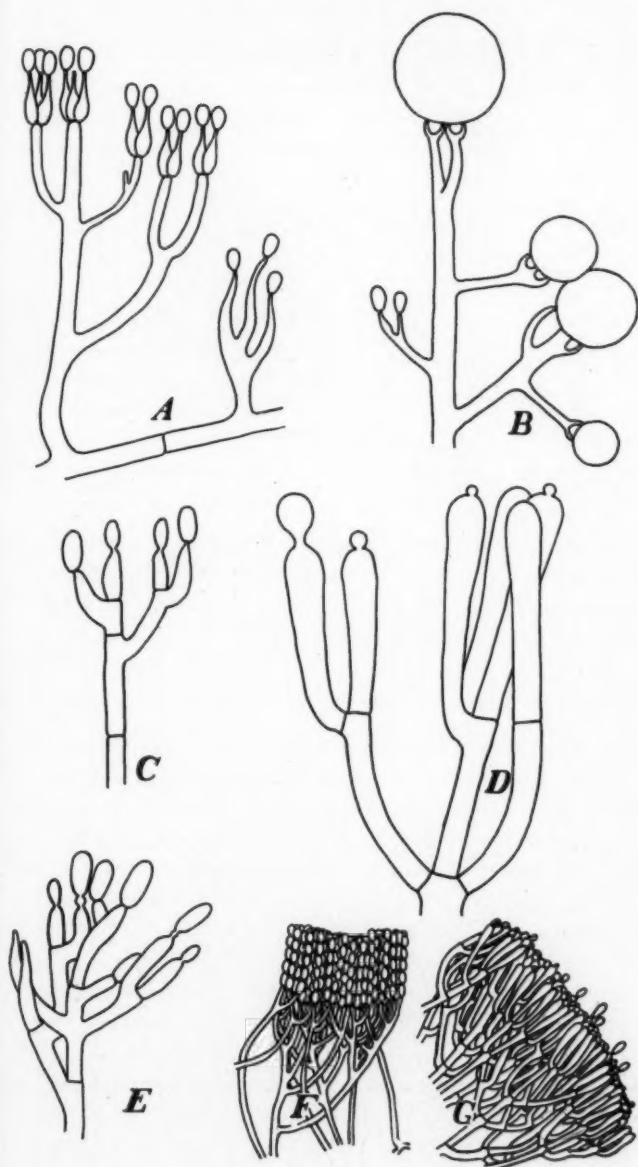


TABLE 1

COMPARATIVE CHARACTERISTICS OF *Gliocladium fimbriatum*, *Metarrhizium glutinosum*, AND *Metarrhizium Anisopliae*

	<i>G. fimbriatum</i>	<i>M. glutinosum</i>	<i>M. Anisopliae</i>
Conidial heads	Round wet balls	Moist masses	Dry columns, conidial chains persisting
Conidia size	6.5-9 \times 2.5-4 μ (Gilman and Abbott)	6-9.6 \times 1.5-3.9 μ	4.8 \times 1.6 μ (Thaxter)
Color	Leaf green	Dusky olive green to olivaceous black	Olive green
Conidiophores	Phialides, flask shaped, arising directly from conidiophore or from metulae, forming individual heads	Branched and penicillate, forming palisade layer in tufts	Simple, branched, or penicillate, forming a palisade layer

The branching of the conidiophores, the shape of the sterigmata, and the tendency of the conidiophores to aggregate into palisade arrangements indicate that *M. glutinosum* is more nearly related to *M. Anisopliae* than to *G. fimbriatum* (FIG. 2).

COMPARISON OF THREE ISOLATES OF METARRHIZIUM GLUTINOSUM

Two other isolates from Maryland soil (2) designated as 1334.1 as 1334.3, were examined morphologically for comparison with isolate 1334.2. Only slight differences in the morphological characteristics have been detected between isolate 1334.1 and isolate 1334.2. However, isolate 1334.3 differs in the cultural characteristics from isolates 1334.1 and 1334.2. The conidia and sterigmata are slightly smaller, and the color of the conidia in the early stages of growth is a lighter green than the other two isolates (table 2). Also, colonies of isolate 1334.3, when grown on a nutrient agar or on cotton fabric, tended to produce growth in concentric rings to a greater extent than the other isolates. These isolates appear, however, to be merely strains of *M. glutinosum* and not specifically different.

TABLE 2
COMPARATIVE CHARACTERISTICS OF THREE ISOLATES OF THE
GENUS METARRHIZIUM

Isolate	Conidia	Color	Sterigmata size	Conidiphore arrangement	Chlamydospores
1334.1	6-9.6 \times 2.9-3.9 μ	Dusky olive green	18-22 μ	Palisade	Brown 7.4-8.1 μ
1334.2	7.5-9.1 \times 2.4-3 μ	Dusky olive green	16-20 μ	Palisade	Brown 7.9-9 μ
1334.3	7.2-8.9 \times 1.5-2.9 μ	Dusky olive green tending to be lighter than Nos. 1 and 2	10-20 μ	Palisade	None observed

SUMMARY

A new species of *Metarrhizium* which is very active in decomposing cellulose is described as *M. glutinosum*. Comparative observations on two other isolates of the same species are reported.

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BRAZILIAN CHYTRIDS. III. NEPHRO- CHYTRIUM AMAZONENSIS

JOHN S. KARLING

(WITH 28 FIGURES)

In moist soil samples collected by the writer in Brazil several new chytrid species occurred which are particularly significant in relation to the position and formation of opercula in the exit papillae or tubes. These species were isolated in the usual manner by watering the soil samples with animal charcoal water and baiting them with fragments of bleached corn or grass leaves, onion skin, cellophane, and other substrata favorable for the growth and development of chytrids. Within five days to two weeks these substrata became heavily infected with numerous chytrids, and from them subcultures were easily made. In subculturing these fungi, five species were isolated which are very similar to well known North American chytrids but which differ characteristically by sunken opercula in the exit papillae or tubes.

The first of these chytrids, which occurred in limited quantities in cellophane, is so similar in development, structure, and appearance to species of *Diplophlyctis* that until the presence of sunken opercula was observed it was regarded for a long time as a member of this genus. Like species of *Diplophlyctis*, it is characterized by monocentric thalli with apophysate sporangia and resting spores. Furthermore, the tip of the mature exit tube deliquesces as in *Diplophlyctis*, but the processes of zoospore maturation and discharge are delayed until a definite operculum is formed in the exit tube. The presence of an operculum, accordingly, excludes this species from *Diplophlyctis*. The only known intramatrical operculate genus which resembles *Diplophlyctis* in structure is *Nephrochytrium*. Therefore, the present chytrid is assigned temporarily to this genus, although it differs in minor characters from the known species of *Nephrochytrium*. The specific name

amazonensis is chosen because the chytrid was collected in the state of Amazonas, Brazil.

***Nephrochytrium amazonensis* sp. nov.**

Sporangiis laevis, hyalinis, pyriformibus, $12-30 \times 50-140 \mu$, sphaericis, $10-60 \mu$, et obclavatis; tubulo exito, $5-7 \times 10-130 \mu$. Operculo $4-7 \mu$ diam. Zoosporiis sphaericis, $5-6.5 \mu$, cum unum globulis sphaericis, $2-2.5 \mu$ diam. Sporiis perdurantibus fusco, ovali, $20-28 \times 30-40 \mu$, sphaericis, $15-35 \mu$; membrana verrucosus, spinosus, aut capillatus; germinatione post brevem quietem confecta, contentis sporae emergentibus ut sporangium tenuis parietis in superficie fiat.

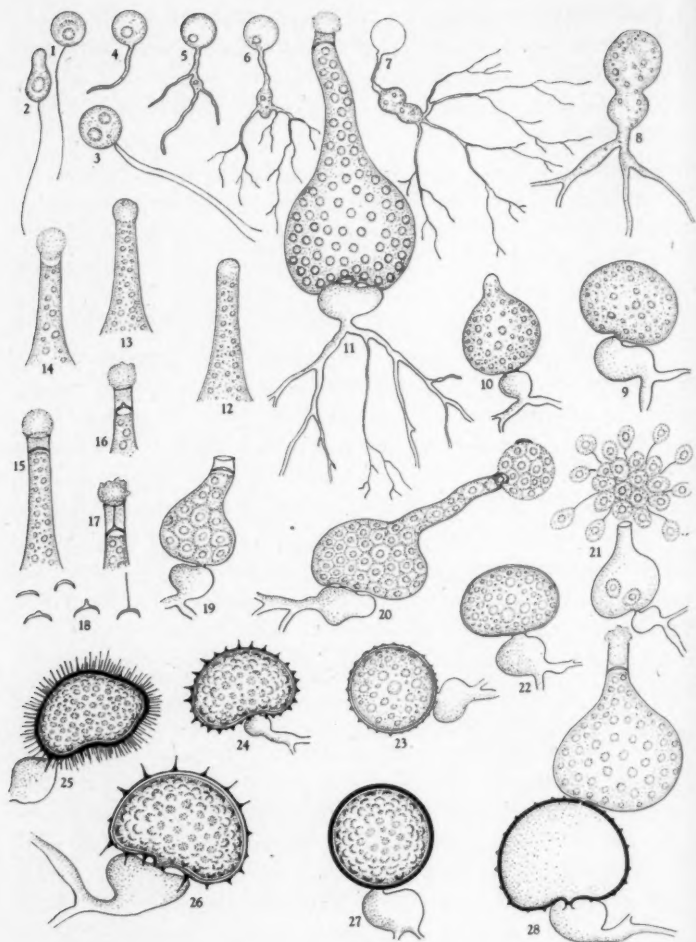
Thallus monocentric, usually intramatrical; consisting of a sporangium or resting spore subtended by an apophysis from which arises an extensive, richly branched rhizoidal system. Sporangia hyaline, smooth, pyriform, $12-30 \times 50-140 \mu$, almost spherical, $10-60 \mu$ in diam., obclavate, flattened and often somewhat kidney-shaped with a short, $5 \times 10 \mu$, or an elongate, $5-7 \times 20-130 \mu$, tapering exit tube. Tip of tube swelling and softening to form a plug of hyaline material; operculum subsequently developed down in exit tube; operculum shallow saucer-shaped, deeper bowl- or cup- and occasionally somewhat cone-shaped, $4-7 \mu$ in diam. Zoospores emerging fully developed and forming a globular mass at the exit orifice before dispersing; spherical, $5-6.5 \mu$, with a large refractive globule and a $35-38 \mu$ long flagellum. Apophysis oval, $5-12 \times 8-22 \mu$, flattened, obpyriform, or almost spherical. Rhizoidal system arising from base of apophysis, extending over a radius of $80-400 \mu$, main axis up to 8μ in diam., richly branched. Resting spores usually oval and somewhat bean-shaped, $20-28 \times 30-40 \mu$, almost spherical, $15-35 \mu$, and sometimes irregular; content coarsely granular and brown; wall dark brown, $2-3 \mu$ thick, usually spiny, sometimes verrucose or covered with numerous short setae, rarely smooth; functioning as prosporangia in germination.

Saprophytic in decaying vegetable debris from a small tributary of Rio Candeias, Amazonas, Brazil.

The life history and development of this species are shown in figures 1 to 28. The diagnosis given above, together with the explanations of these figures, is sufficiently complete so that a detailed description of the developmental cycle is unnecessary. Accordingly, the present discussion will be confined to an emphasis on the similarities and differences between *N. amazonensis* and the known species of *Diplophlyctis* and *Nephrochytrium*. In the

former genus, according to the author (2), the incipient sporangium develops first as a swelling at the tip of a branched germ-tube, while the apophysis forms subsequently as a second swelling above the young sporangium. In *Nephrochytrium*, on the other hand, the apophysis is formed first, and the sporangium grows out later as a bud from the large apophysis as has been described by Couch (1), Whiffen (8), and the author (4). This characteristic type of development and the presence of an operculum are regarded as the distinctive characters of *Nephrochytrium*. In *N. amazonensis* an operculum is present, but as far as the writer has been able to determine from observations of a limited number of germinating zoöspores and young thalli, the sporangium and apophysis develop as in *Diplophlyctis*. At least no sharply defined cases of a sporangium budding out from an apophysis have been seen. This phase of development, however, needs more intensive study before definite conclusions can be drawn. Figures 5 and 6 show conspicuous swellings in the branched germ-tubes, while in figures 7 and 8 the apophysis and sporangium are well marked and continuous, although it is not evident that the latter has grown out of the former. The young thallus shown in figure 8 is exceptional in that the connection between apophysis and sporangium is very broad. Usually the isthmus between them is quite narrow (FIG. 9, 10, 18).

Other variations of *N. amazonensis* may be noted at this point. While the sporangia are predominantly pyriform, oval, slightly apressed and bean-shaped, they vary considerably in shape. This is particularly true when they are deeply buried in the substratum. In thick soft pieces of cellophane the sporangia may become greatly elongate, cylindrical, tubular and contorted and vary from 120 to 400 μ in length by 10–30 μ in diameter. Under similar conditions they may also become very irregular in shape. In old cellophane cultures in which the pieces of substrata have become surrounded by a slimy substance, the thalli may sometimes develop extramatrically with the sporangium, or resting spore, apophysis, and rhizoidal system completely outside of the substratum. In the development of such thalli, zoöspores germinate with a germ tube and give rise to the sporangia, apophysis and rhizoids in the same manner as is shown in figures 4 to 7. Completely extramatrical



FIGS. 1, 2, spherical and amoeboid zoöspores with a large refringent globule; 3, large abnormal biflagellate zoöspore; 4, 5, germination of zoöspores; 6, 7, development of young sporangium and apophysis; 8, young thallus with apophysis and sporangium continuous; 9, 10, later stages of sporangium development; 11, mature sporangium with operculum and plug of hyaline material in exit tube; 12-15, swelling and deliquescence of tip to exit tube, formation of hyaline plug and operculum; 16, 17, variations of hyaline plug and position of opercula; 18, variations in shapes of opercula; 19, sporangium

thalli are very exceptional, but their occurrence nevertheless indicates how variable chytrids may be in relation to their hosts and substrata.

The distinctive character of this species, however, is the position of the operculum and the changes involved in its development. After the exit tube has been fully formed, the tip begins to swell slightly (FIG. 12, 13), while its bounding wall deliquesces. As a result, a plug of hyaline material forms at the tip and extends for a short distance down into the tube. While these changes are taking place, the more optically heterogeneous protoplasm in the tube contracts downward and its surface usually becomes concave (FIG. 14). Later the border becomes convex and thickens, and eventually an operculum is formed at the surface in much the same manner as the author (5) has described for *Nowakowskiella granulata*. The position of the operculum depends to a large extent on the depth to which the protoplasm retracts in the tube. The opercula are usually shallow saucer- or bowl-shaped (FIG. 18), but occasionally they are pointed, cone-shaped, and surmounted by a peg or tenuous hair.

The plug of hyaline material usually deliquesces and disappears before discharge of the zoöspore occurs (FIG. 19). When the zoöspores emerge, the operculum is pushed out so quickly that its presence may be overlooked unless the initial stages are observed. Occasionally it may be found adherent to the enlarging mass of zoöspores on the outside (FIG. 20).

As in *Diplophlyctis*, the resting spores appear to be formed in the same manner as the sporangia, and so far no evidence of the fusion of thalli like that reported by Sparrow (7) has been observed. The young spores may be easily recognized by their thicker walls (FIG. 22) and more refractive content. As they

shortly before discharge of zoöspores; 20, zoöspores emerging and forming a globular mass at exit orifice; operculum at surface of zoöspore mass; 21, dispersal of zoöspore mass; 22, incipient resting spore; 23, later developmental stage showing rudiments of spines on wall; 24, mature spore with numerous abruptly tapering spines and coarsely granular content; 25, irregular mature spore covered with numerous short setae, among which are interspersed a few spines; 26, mature spore with a few long spines; 27, exceptional smooth, spherical resting spores; 28, germination of resting spore.

mature, the wall begins to turn brown, and incipient warts or spines appear on the surface (FIG. 23). The refractive globules become more highly dispersed so that the content of the spores takes on a coarsely granular appearance (FIG. 25-27). The mature spores may be warty, echinulate, spiny and sometimes covered by short fine hairs. In three cases observed, the walls were smooth (FIG. 27). The spines may be numerous or sparse, very short or fairly long, as is shown in figures 24, 26, and 28. After two to four months under laboratory conditions in New York, the resting spores germinate and form hyaline evanescent sporangia on their surfaces (FIG. 28). In such sporangia the tip of the exit tube deliquesces and forms a plug of hyaline material, while the operculum develops down in the tube in the same manner described above for the primary sporangia. With the exception of the formation of an operculum, the resting spores thus germinate like those of *Diplophlyctis intestina* (Karling (3)) as far as is now known.

While it is not conclusively certain whether or not the sporangium of *N. amazonensis* develops from the apophysis as in other members of the genus, this species is nevertheless included in *Nephrochytrium* for the time being. Further studies on its development as well as the discovery of other similar species may possibly show that the formation of the sporangium from an apophysis is not so distinctive and diagnostic of the genus as the presence of an operculum. *Nephrochytrium amazonensis*, at any rate, is a significant chytrid because of its striking similarity of structure to species of *Diplophlyctis*. This similarity together with the deliquescence of the tip of the exit tube prior to operculum formation suggests that the present fungus may possibly be a transition form between the two genera. While there is no indisputable evidence at hand of such a transition, it is none the less stimulating to postulate that the operculum of *Nephrochytrium* may have evolved through changes of nature shown in figures 12 to 15 from an operculate *Diplophlyctis*-like ancestor.

The discovery that an operculum develops although the tip of the exit tube deliquesces and forms a plug of hyaline material emphasizes the need for more intensive study of species with exit tubes or papillae of this type and appearance. *Rhizidium lignicola*

Lindau (6), for instance, is a saprophytic apophysate species with exit tubes very similar in appearance to those of *N. amazonensis*, and it is not improbable that further studies may show the presence of sunken opercula in this species. This may perhaps prove to be true of Zopf's (9) *Amoebocytrium rhizidioides* also.

SUMMARY

Nephrochytrium amazonensis occurs as a saprophyte in decayed vegetable debris in moist soil samples collected from the Rio Candeias in Amazonas, Brazil. It is strikingly similar in structure to species of *Diplophlyctis*, but forms an operculum in the exit tube after the tip has deliquesced and become filled with a plug of hyaline material. Because of the presence of an operculum it is included in the genus *Nephrochytrium*.

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NEW GENERA OF FUNGI ¹

ROLF SINGER ²

When the flora of the flowering plants of the tropics is compared with the temperate flora, it will be obvious that many temperate elements are not represented in the tropics while, *vis versa*, the tropics are rich in forms unknown in the North. This refers to species as well as to genera, and even families. In mycology, however, these facts do not express themselves in taxonomic terms because most tropical species were forced into one or another of the artificial Friesian genera. When a turn toward smaller natural genera had begun, the data on tropical species were comparatively scarcer than on temperate forms, and, at the same time, the tropics were yielding many interesting novelties while the still numerous new species from temperate countries more or less remained within the framework of the classification established for them during the last years.

It is not surprising, therefore, that the mycologist, when trying to work out the flora of some tropical regions, still discovers many forms which belong in genera hitherto unknown to Science. This was shown, in the Old World's tropics, by Roger Heim's studies on the fungi of Madagascar, and it became still more manifest to the writer when he visited South Florida with its neo-tropical vegetation. The theory of the prevalence of cosmopolitism in fungi, in the writer's opinion, ought to be abandoned altogether.

1. *Boletochaete* Sing. gen. nov.

Boletacearum genus, sporis sub microscopio brunneolo-hyalinis vel melleo-brunneolis, levibus, fusoido-ellipsoideis vel ovoideo-ellipsoideis; basidiis haud voluminosis; cystidiis numerosis; setis hymenialibus coloratis numerosis;

¹ Contribution from the Farlow Herbarium and Laboratories of Cryptogamic Botany no. 209.

² The writer wishes to thank Dr. Fred J. Seaver, Head Curator, The New York Botanical Garden, for a loan of the type collection of *Leucomyces mexicanus* Murr., and also Dr. David H. Linder, Curator, Farlow Herbarium, Harvard University, for various tropical materials from special collections.

tramate hymenophori subregulari (haud distincte laterali) in adultis; hyphis haud fibuligeris; hymenophoro tubuloso, ad stipitem adnexo; stipite cylindraceo vel ventricosco.

The type species is *Boletus spinifer* Pat. & Baker, Jour. Straits Branch R. A. Soc. No. 78, p. 69. 1918. We have studied the type preserved at Farlow Herbarium. Other species belonging in this new genus are: *Xerocomus* sp. Heim, Bol. Soc. Brot. 13: 53. 1938, and a new species which shall be described here.

The new combination ***Boletochaete spinifera*** (Pat. & Baker) Sing. is proposed.

Boletochaete brunneosetosa Sing. sp. nov.

Pileo sordide cerasino, levi, subvelutino, convexo, 20–32 mm. lato; cuticula ex hyphis catenulatis $20\text{--}32 \times 12\text{--}14 \mu$, erectis et irregulariter palisatis, nonnullis autem jacentibus, haud densis, membrana $1\text{--}1.5 \mu$ crassa in nonnullis, tenuiore autem in aliis, institutis, apice rotundatis, intus pigmento dissoluto brunneo impletis, pigmento intercellulari nullo ornatis consistente.—Tubulis porisque olivaceo-luteis, usque ad 8 mm. longis, subtus convexis, adnexis depressisque circum stipitis apicem, poris majusculis (15 pro 1 cm.); sporis brunneo-melleis, levibus, oblongo-ellipsoideis, subfusiformibus, depressione suprahilari saepe distincta, $12\text{--}13 \times 4.5\text{--}5.5 \mu$; basidiis $22\text{--}32 \times 8\text{--}9.5 \mu$; cystidiis versiformibus (fusoido-ventricosus vel clavatis vel fusoido-acutis), hyalinis, tenui-tunicatis, numerosis, $33\text{--}66 \times 6\text{--}14 \mu$; setis hymenialibus membranaceis, brunneis, levi, crassa ($1.5\text{--}3.5 \mu$), saepe subhyalina in parte basali ibidemque tenuiore, vel unicolori aequalique instructis, acutissimis, fusoides, rarissime spina laterali gaudentibus, numerosis, $55\text{--}95 \times 9\text{--}12.5 \mu$; tramate hymenophori subregulari (haud distincte laterali) in adultis, mediostrato haud densiore neque obscuriore atque vix distincto, strato laterali concolori (pallidissime melleo-hyalino), in tertia externa leniter divergente; hyphis constanter defibulatis.—Stipite concolori cum pileo, ad basin albo, subvelutino, levi, glabro, nudo, aequali, ad ipsam basin autem attenuato, solido, rigido, $17\text{--}40 \times 2\text{--}5$ mm.—Carne alba, solida; hyphis haud fibuligeris; odore saporeque notabilibus nullis.—Habitatio: Ad humum in silva. Aprili mense. Nengbe, Liberia, Africa Occidentalis. Legit G. W. Harley.

This species differs from *B. spinifera* in having elongate, more deeper colored spores, slender, cylindric stipe, and red pileus and stipe. Another African species, *Xerocomus* sp. Heim, described from Madagascar, which seems to come much closer to *B. brunneosetosa* than *B. spinifera*, still differs in color of the pileus and the stipe and also of the tips of the setae which are said to be olivaceous-yellow. Heim is right comparing his species with *Xerocomus*. As long as there was no proper new genus described for the setae-bearing boletes, *Xerocomus* certainly was the genus

most closely suggesting affinity. When younger stages of these interesting African and Asiatic species become available, it will be possible to decide whether *Boletochaete* actually is related to *Xerocomus*. If the trama has the same structure in young stages as in the adult ones studied by us, this question may be answered affirmatively. If however the young tube walls have a bilateral trama it would seem to us that *Boletochaete* is closer to a group of boletes that though having the external appearance of *Xerocomus*, and in some instances were interpreted as such, actually have bilateral trama, and should be treated as belonging in the genus *Pulveroboletus* in a larger sense. The decision as to whether *Boletochaete* is closer to *Xerocomus* or to *Pulveroboletus* can only be made after young stages of one or all of them have been studied. The examination of the adult stages available would suggest a trama of the *Xerocomus* type, but previous experiences with *Pulveroboletus Ravenelii* convince the writer that in some cases the trama tends to become more uniform in age. In any case, the setae of *Boletochaete* distinguish this genus sufficiently from all known genera of Boletaceae, and certainly justify the erection of a separate genus for these tropical fungi.

2. *Phaeogyroporus* Sing. gen. nov.

Boletacearum genus; sporis in cumulo olivaceo-brunneis (inter "Isabella color" et "light brownish olive" Ridgwayi mediis), levibus, breviter ellipsoideis; basidiis haud voluminosis; cystidiis praesentibus, haud exiguis; hyphis fibuligeris; hymenophoro tubuliformi, ad stipitem simpliter adnexo vel distincte depresso, haud decurrente, poris minutis vel mediis, tubulis longiusculis.

The type species is *Boletus Braunii* Bres. sensu nostro as preserved at Farlow Herbarium. Another species belonging here is *Boletus tropicus* Rick sensu nostro as preserved in the Patouillard Herbarium, Farlow Herbarium, under the name of *Boletus crassus*.

The new combinations *Phaeogyroporus Braunii* (Bres. sensu Sing.) Sing. and *Phaeogyroporus tropicus* (Rick) sensu Singer, comb. nov. are proposed.

This genus is close to *Gyroporus* macroscopically, and does not recall *Gyrodon* in this regard; microscopically however, it reminds one of *Gyrodon*, or *Paragyrodon* in more than one character. The spore print was only two years old when first seen by the

writer *i.e.* rather fresh. It is impossible for a *Gyroporus*, even if the improbable should be true that the spores have measurably changed their color during these two years. Spore preparations of species of *Gyroporus* even if kept for many years never attain a color as deep and as olivaceous as shown in our spore preparation of the species we now call *Phacogyroporus Braunii*. This preparation was obtained by the collector, G. W. Harley. We are convinced that his specimens are genuine *Boletus Braunii* Bres., as described and figured by Bresadola from the Camerouns. However, in studying Agaricales we have found that sometimes the most improbable turns out to be correct, and therefore, maybe overcautiously, we prefer to choose as the type of the new genus not the type of Bresadola's species which we have not seen, but Harley's collection mentioned above. By an unfortunate coincidence, the second species belonging in *Phacogyroporus*, is known to the writer only by a well preserved specimen in the Patouillard Herbarium under the name *Boletus crassus* which we cannot find in Rick's papers. Yet, this specimen was sent to Patouillard by Rick in 1906, and we think it fits very well in Rick's description of *Boletus tropicus*. Our guess is that Rick discovered shortly before publishing his first account that the name *Boletus crassus* was preoccupied, and therefore changed it. But as authentic material under the correct name is not available, we cannot definitely prove the identity. The same species represented in Patouillard's Herbarium, and collected in Brazil, has also been collected by Harley in Liberia.

3. *Xanthoconium* Sing. gen. nov.

Boletacearum genus; sporis in cumulo vegeto luteolis, sub microscopio aureis, levibus, cylindraceis vel fusoido-cylindraceis; basidiis haud voluminosis; cystidiis praesentibus; tramate ditinctissime laterali; hyphis haud fibuligeris; hymenophoro tubuloso, simpliter adnato vel adnexo aut frequentius circum stipitem depresso, poris minutis; stipite aequali vel ventricoso, glabriusculo, levissimo, solido; pileo haud scrobiculato; sapore miti; carne immutabili.

The type species is *Gyroporus stramineus* Murr., Bull. Torrey Club 67: 62. 1940. Other species belonging here: *Boletus affinis* Peck, Ann. Rep. N. Y. State Mus. 25: 81. 1873.

The following combinations are proposed: *Xanthoconium*

stramineum (Murr.) Sing. comb. nov. and **Xanthoconium affine** (Peck) Sing. comb. nov.

Studies at the type localities, and type studies in the Herbarium of the Agricultural Experiment Station of the University of Florida at Gainesville enabled the writer to obtain the necessary data on the strange group of species described by Murrill and Snell as white spored *Gyropori*, and separated by the latter under the new generic name *Leucogyroporus*. *Leucogyroporus pisciodorus* (Murr.) Snell, the type species of the genus *Leucogyroporus*, actually has what is called "pink" spores *i.e.* the fresh spore print on white paper is "vinaceous fawn," and is a rare variety between "fawn color" and "wood brown" Ridgway. Since there is no appreciable generic character to prevent this species from being incorporated in the pink spored genus *Tylopilus*, and since *Leucogyroporus pisciodorus* is, as the existing types clearly show, nothing else but *Boletus tabacinus* Peck, we think that the correct name for this species is ***Tylopilus tabacinus*** (Peck) Sing. comb. nov. and the genus *Leucogyroporus* would become a synonym of *Tylopilus*. On the other hand, *Leucogyroporus stramineus* (Murr.) Snell is not a *Tylopilus* unless the latter genus is amended drastically. The narrow, golden yellow spores and the smooth, glabrous stipe, the yellow to rusty yellow spore print, and the context which neither tastes bitter nor changes color on exposure, combined with the absence of pits on the pileus, sufficiently separate *Leucogyroporus stramineus* from *Tylopilus*. The characters separating *Tylopilus* from *Boletus* *sensu stricto* are about as many and as important as the ones separating *Xanthoconium* from *Tylopilus*, and therefore, if *Tylopilus* is considered as a distinct genus (as I think it should) though related to *Boletus*, then, *Xanthoconium* is a third good genus of the same tribe. We want to insist, at this occasion, on our previous statements that there are no boletes with white spores. All species included in the genus *Leucogyroporus* by Snell actually produce a colored spore print, and the indication that the spores were white, probably originated in an authentic spore preparation of Murrill's where the paper stayed white, but, as a careful examination revealed, there was not a single spore on it; it may also have originated with the observation that, under certain circumstances, the single spore

under the microscope *e.g.* in *Tylophilus tabacinus* (Peck) Sing. and *T. Rhoadsiae* (Murr.) Murr. seems to be or actually is hyaline. But this also is the case with spores of *T. felleus* or *T. plumbeo-violaceus*, and as a matter of fact, the spore print is pink in all these species. It is true that the spore print of *Filoboletus* Henn., and possibly *Polyphoroletus* Snell is pure white to creamy white. However, as the writer shall show in a paper which is now in preparation, the former is an agaric (Marasmiaceae), and the latter is a *Scutiger*; they therefore cannot be considered as boletes.

4. *Callistosporium* Sing. gen. nov.

Tricholomatacearum genus; pileo hygrophano vel sicco, cuticula ex hyphis repentibus composita; carne tenui; hymenophoro lamelloso, lamellis angustato-adnexis, vel adnatis, vel emarginatis; sporis ellipsoideis, levibus, per multis pigmenti corpusculo purpureo vel atroilacino aut pigmenti solutione rubro-rosea vel lilacina impletis, membrana inamyloidea, tenui, hyalina instructis; pleurocystidiis nullis; tramate lamellarum regulari, haud amyloideo; stipite centrali, subcartilagineo, tenui; hyphis omnibus fibulis destitutis. Habitatio: Ad basin palmarum et ad ligna.

The type species is *Gymnopilus palmarum* Murr., Bull. Torrey Club 66: 32. 1939. Other species belonging in this genus are: *Collybia Heimii* Sing., Revue de Mycologie 2: 234. 1937, and a species which we discovered in the Herbarium of the Agricultural Experiment Station in Gainesville, Fla., collected and named by W. A. Murrill (as *Psilocybe*) but still unpublished. This species will be described here below.

The following combinations are proposed: *Callistosporium palmarum* (Murr.) Sing. comb. nov.; *Callistosporium Heimii* (Sing.) Sing. comb. nov.

Callistosporium psilocybe Murr. & Sing. sp. nov.

Pileo uniformiter melleo-subumbrino, "carob brown" (Ridgway) in siccis, hygrophano, levi, glabro, campanulato vel convexo, in siccis centro depresso, in statu vegeto haud plane expanso, 25 mm. lato; cuticula ex hyphis repentibus consistente.—Lamellis pallidis leniterque melleo-tinctis, "carob brown" (Ridgway) in siccis, brevioribus intermixtis, ad aciem erosis, moderate latis, confertis vel confertissimis, adnatis vel emarginatis; sporis $5-6.2 \times 3.3-4 \mu$, ellipsoideis, poro germinativo destitutis, hyalinis vel roseo-vinaceis quia succo cellulari lilacino impletae sunt, saepe uno vel duobus corpusculis crystalliformibus pigmenti lilaceis intracellularibus ornatis, membrana hyalina et tenui, inamyloidea, levi gaudentibus; basidiis $16.5-26 \times 4.6-6.5 \mu$, succo hyalino vel lilaceo impletis, saepe guttulis et crystallis lilaceis ornatis, tetrasporis; cystidiolis fusiformibus vel fusideo-lageniformibus vel basidiomor-

phis, admodum sparsis, hyalinis; acie lamellarum homomorpha, cheilocystidiis nullis; cystidiis veris nullis; tramate lamellarum regulari, ex hyphis subparallelis vel subintertextis haud fibuligeris consistente.—Stipite concolori, levi, glabro, aequali, leniter compresso, subcartilagineo, 40×5 mm.—Carne tenui, mellea, subtenaci; hyphis haud fibuligeris; sapore amarissimo.—Habitatio: Ad lignum quercinum putridum in silva frondosa paludosa ("low hammock"). Octobri mense. Rarissime. Juniper Springs, Floridae, U. S. A. Leg. W. A. Murrill.

As for the type species, *C. palmarum*, we find, that by a strange coincidence, an *Agaricus* (*Collybia*) *palmarum* has been described before by V. B. Briganti in his *Historia Regni Neapolitani*, Naples 1848 which may very well be the same fungus. Since Murrill described his species as *Gymnopilus palmarum* Murr., the existence of an earlier *Collybia palmarum* does not invalidate Murrill's name, and in the case Briganti's species should be the same as Murrill's—in spite of a few differences—the name *Callistosporium palmarum* will stand, but the name of the author will have to be changed.

The new genus *Callistosporium* is very remarkable for its peculiar intracellular pigment of the spores and, in some cases, also of the basidia. An additional very important character is the clampless septa of the hyphae. The characters of these fungi do not seem to indicate any relationship with the Coprinaceae (Stropharioidaeae), nor with such pale spored forms as *Psathyrella subcernua* (Schulz.) Sing. comb. nov. (*Agaricus subcernuus* Schulz., *Psilocybe conissans* Peck), or "*Hypholoma*" *Agaves* Maire (Scotosporioideae). We therefore think that the lilaceous or purple color of some spores, and possibly a colored spore print should not schematically be considered as a sufficient evidence for eliminating this genus from the Tricholomataceae where its affinities appear to be. It differs from *Collybia* in having no clamp connections, from *Tricholoma* in having intracellular pigment, from *Omphalia* in having non-decurrent lamellae and the center of the pileus depressed only in dried specimens. From all three genera it differs in having colored spores.

5. *Nothopanus* Sing. gen. nov.

Tricholomatacearum genus; pileo rarissime centraliter, plerumque admodum excentrice vel lateraliter stipitato vel affixo, carne molliusculo-subcarnosa in juvenilibus, tenaci in adultis ex hypharum membranae crassitie; sporis in cumulo albis, sub microscopio hyalinis, ellipsoideis vel subglobosis,

nunquam cylindraceis, tenuitunicatis, haud amyloideis; basidiis granulatione carminophila destitutis, cystidiis nullis; tramate lamellarum regulari, haud amyloideo; lamellis plus minusve adnatis vel decurrentibus; stipite breviusculo vel nullo; hyphis fibuligeris; habitatio: ad ligna putrida vel viva.

The type species of this genus is *Agaricus (Pleurotus) eugrammus* Mont. Other species belonging in this genus as autonomous species or forms of *N. eugrammus* are numerous. The most important ones are *Xerotus guadelupensis* Pat. and *Xerotus vinosofuscus* Bres.

The new combinations ***Nothopanus eugrammus*** (Mont.) Sing. comb. nov., ***Nothopanus guadelupensis*** (Pat.) Sing. comb. nov., ***Nothopanus vinosofuscus*** (Bres.) Sing. comb. nov. are proposed.

Fungi belonging to *Nothopanus eugrammus* either as a synonym, or a form, and others, congeneric with it, have been described in the following genera: *Agaricus*, *Panus*, *Panellus*, *Xerotus*, *Xerotinus*, *Pleurotus*, *Marasmius*. Patouillard seems to have included this group in *Xerotus*, and Murrill, using Reichenbach's nomen novum *Xerotinus*, aside of making *N. eugrammus* a *Panellus*, indicates two American species of the former genus which both belong in *Nothopanus*. We do not think that the generic name *Xerotus*, or *Xerotinus* can be used for any well known group, at least at present. There is no doubt that the type species of the Friesian genus is *Xerotus afer* Fr., and Murrill cites this same species as the type of *Xerotinus*. Lloyd indicates that there is a specimen of this in Sweden, and he gives an illustration of it in Mycol. Notes 7: 1154, fig. 2259. 1922. Without microscopical data, however, all that can be said about this plant, is pure guess work. It may be that it belongs to a species of a well known genus, differing only in abnormally forking gills, a character which, in our opinion, hardly is of generic importance. But there is little likelihood that *Xerotus afer* would eventually turn out to be a *Nothopanus*. The dark color of most of its parts would suggest another group of fungi which usually is called *Xerotus*, but even in this case it is very doubtful whether they are congeneric. The group I have in mind, is *Anthracophyllum*, as I would prefer to call this genus at present, disregarding the mistake some authors originally made about the color of the spores. Actually, the spores

of all these species (or forms) are hyaline, and what black particles may have been observed, are carbonaceous pigment bodies which dissolve to a characteristic green solution when brought under the microscope in an ammoniacal medium. The spores are ellipsoidal to subcylindric, non-amyloid, smooth, thin-walled; hyphae with clamp connections. Lloyd also states (referring to *Anthracoephyllum*) that "the original idea" (i.e. the type of *Xerotus afer*) "was lost sight of, however, in these additions. . . ." We may add that in including *X. guadelupensis* and *X. vinosofuscus*, and other species, here reunited as *Nothopanus*, Patouillard and Bresadola had still further lost sight of the original idea. Therefore, it has become necessary to distinguish the group centering around *Agaricus eugrammus* Mont. as a new genus.

6. *Smithiomyces* Sing. gen. nov.

Leucoprinnacearum genus; pileo levi, pelliculae tenuissimae deterrentis fragmentis oblecto, sicco, haud squamoso, pellicula ex hyphis atque sphaerocystis Russulacearum fere modo intermixtis consistente; lamellis permultis, liberis, haud attingentibus; sporis albis in massa, minutis, neque amyloideis nec pseudoamyloideis, levibus; carne molli, alba; habitatio: ad humum et ad lignum putridissimum in silvis subtropicalibus vel tropicalibus.

The type species of the genus is *Leucomyces mexicanus* Murr. (*Amanita mexicana* Murr., *Venenarius mexicanus* Murr.).

The new combination *Smithiomyces mexicanus* (Murr.) Sing. is proposed.

This remarkable species and genus has been collected once by Murrill, in Mexico, and many times by the writer in Highlands and Dade Counties of the State of Florida, U. S. A. It differs from all other forms of this family in having the peculiar heteromorous structure of the fragmentary veil on the surface of the pileus as described above. Aside from that, it differs from *Lepiotella* in white spore print, presence of clamp connections, absence of cystidia, dry pileus; from *Lepiota* in having non-pseudoamyloid spores, and from *Cystoderma* in having free lamellae. It reminds one macroscopically of *Amanita*, but is readily distinguished from the *Amanitaceae* in having regular trama and a combination of size and shape of spores that does not occur in that family. This is most certainly a good new genus. For a moment, we considered using the name *Leucomyces*, but this would have been too

obviously in contradiction with the International Rules (see also Rogers on *Cristella*, *Mycologia* 36: 78. 1944). Aside from this, it would also be opposed to the intention Murrill had when digging out this pre-Friesian name at this one occasion. He then thought *Leucomyces* Batt. under the rules of the American Code, would be the valid name for what we now call *Amanita*, but later replaced this name by *Venenarius* Earle. Thus *Leucomyces mexicanus* Murr. cannot be the type of the genus *Leucomyces*, but the type must be one of the few species described and figured by Battarra under this generic name. These species, though hardly determinable at present, certainly do not belong to *Smithiomyces* since this latter does not occur in Europe, and none of Battarra's species shows the slightest similarity with it. Consequently a new generic name is needed for *L. mexicanus* with this latter species as type. We are glad to dedicate this genus to Alexander H. Smith whose contributions to American Agaricology during the last decade are among the most outstanding advances in this particular field.

7. *Pyrrhoglossum* Sing. gen. nov.

Cortinariacearum genus; pileo astipitato vel pseudostipite superiore praedito, vel possibiliter in aliis speciebus minus notis brevissime lateraliter stipitato, plerumque asymmetrico, lobato lacerove, rarissime subcirculari integroque; lamellis sporarum massae causa laetissime ferrugineis in adultis; sporis breviter ellipsoideis, ferrugineis, grosse verrucosis, disco levi suprahilari poroque germinativo destitutis; cystidiis veris nullis; cheilocystidiis inconspicuis; tramate regulari, flavo; hyphis fibuligeris; habitatio: ad lignum, in regionibus tropicalibus.

The type species of the genus *Pyrrhoglossum* is *Agaricus* (*Crepidotus*) *pyrrhus* Berk. & Curt., or *Crepidotus pyrrhus* (Berk. & Curt.) Sacc. *Crepidotus laceratus* Pat. from Guadeloupe is a synonym, and so is *Agaricus* (*Crepidotus*) *pyrrhus* var. *leiospora* Berk. and Curt. I have carefully compared all the types concerned, and cannot find any real difference between these plants. The allegedly smooth spores of the variety, actually are just as verrucose as they are in the type form.

The new combination ***Pyrrhoglossum pyrrhus*** (Berk. & Curt.) Sing. comb. nov. is proposed.

This new genus is very well defined by its pleurotoid habit, combined with bright ferruginous warty spores. In fact, the anatomy

of the cuticle, the trama, and the hymenium is the same in *Pyrrhoglossum* and in *Gymnopilus* Karst. (*Fulvidula* Romagnési, *Flammula*, sect. *Sapineae* aut.). The chemical reaction with KOH also is identical in the last named genera. Thus, what *Crepidotus* is to *Ripartites*, *Pyrrhoglossum* is to *Gymnopilus*. There is a natural hiatus between both of these genera, the difference in the spores being more conspicuous in *Ripartites-Crepidotus*, while the difference in the shape of the carpophore is more abrupt in *Gymnopilus-Pyrrhoglossum*. There are analogous pairs in other families, such as *Leucopaxillus* and *Lentinellus*, *Crinipellis* and *Chactocalathus*, *Clitocybe* and *Pleurotus*. It is true that in some other groups, as for example in the genus *Lentinus*, or in *Paxillus* or *Clitopilus*, there is no abrupt cleavage between pleurotoid and centrally stipitate forms, and it has turned out that their subdivision into centrally and laterally and not stipitate species by Karsten and others did not produce well defined genera. While, as a general rule, we do not think that the above characters can serve as a base for splitting a homogenous genus into two or three genera, we are convinced that the opposite doctrine would be just as wrong. There is evidence that in some cases the presence or absence of the stipe may be the main character distinguishing two related genera, and still these genera would be separated not merely artificially, but according to evolutionary lines. It seems to us that, in the case of *Pyrrhoglossum*, we have to do with an independent line of phylogenetic development particular to the tropics. A practical reason for erecting a new genus is the improbability that anybody trying to determine *Pyrrhoglossum* would look for it in *Gymnopilus*, as is clearly shown by the history of the plants described so far. The affinity of *Gymnopilus* and *Pyrrhoglossum* has been established only on the base of a very detailed microscopical analysis and additional chemical data.

Another species which will probably be transferred to *Pyrrhoglossum* as a second species, is *Agaricus croceosanguineus* Mont. from Chile, also considered to be a *Crepidotus* in citations previous to this.

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AN EXPERIMENTAL STUDY OF ALTERNATION OF GENERATIONS IN *ALLOMYCES ARBUSCULUS*

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INTRODUCTION

The genus *Allomyces* has been known since 1911 when a single species, *Allomyces arbusculus*, was discovered in India by Butler (1). Although Weston (12) suspected sexuality in a form he isolated at Los Banos, Philippine Islands, as early as 1918, it was not until 1929 that an account of sexuality in this genus was published by Kniep (9). Kniep's work was done on *Allomyces javanicus*, and on what we now know as *Allomyces arbusculus*.

The life cycles of the two species mentioned above and of other species, discovered since and assigned to that section of the genus known as *Euallomyces*, have been a matter of much interest to mycologists. In 1930 Kniep (10) found that a regular alternation of generations existed in *Allomyces javanicus* and in the species now recognized as *Allomyces arbusculus*. He showed that the sexual plant arose from a zoospore from a resistant sporangium on an asexual plant, while the asexual plant was derived from a zygote or from a zoospore from a thin-walled zoösporangium on an asexual plant. Kniep's conception of the life cycle was that the sexual plant was haploid in character, the asexual plant diploid, with meiosis occurring in the resistant sporangium. As evidence of this relationship, Kniep presented measurements of the volumes of nuclei in the hyphae of sexual and asexual plants. There was an approximate 1:2 ratio, the actual figures being 1:2.12. This interpretation of the life cycle of *Allomyces javanicus* was confirmed by Sörgel (11) in 1936. He likewise found a close 1:2 ratio between the volumes of nuclei in sexual and asexual plants. He found that this relationship also existed between the nuclei in hyphae of sexual and asexual plants of *Allomyces arbusculus*. Emerson (2) in 1941 found additional support for Kniep's origi-

nal interpretation in evidence derived from his genetic studies. It can probably be concluded, on the strength of the evidence presented above, that in that section of the genus now known as *Euallomyces* there is a regular alternation of generations between a haploid sexual and a diploid asexual plant with meiosis occurring in the resistant sporangium. Hatch (7) questioned this interpretation, suggesting that meiosis occurred in the germination of the zygote. A more careful analysis of his material, to be reported upon in another paper, has convinced him that there is really no evidence that meiosis occurs at zygote germination.

Although it is probably true that there is a *regular* alternation of generations between sexual and asexual plants with meiosis occurring in the resistant sporangium, there is much evidence that there is also an irregular life cycle for at least certain members of the *Euallomyces*. In a species of *Allomyces* collected by Weston in Alabama in 1912 thousands of resistant sporangia zoöspores were germinated, but no sexual plants were seen. Sörgel (11) found that in *Allomyces arbusculus* the zoöspores of resistant sporangia sometimes gave rise to asexual rather than sexual plants. Furthermore, in a comprehensive study of many *Euallomyces* isolates Emerson (2) found that "in some strains R. S. zoöspores gave rise to sporophytic plants so regularly that it was only after repeated germination of resistant sporangia under widely different conditions that sexual (gametophytic) plants were finally obtained." Emerson concluded that "We have a series of forms, grading gradually from those which regularly produce a sexual stage to those which apparently form sexual plants very rarely."—"Exactly what conditions exert a controlling effect on the R. S. zoöspores and determine whether they shall develop into sexual or asexual plants is not at all clear at present. Sörgel (11) noted, however, that when R. S. zoöspores of *A. arbusculus* (*Kniepii*) germinated very soon after emergence from the sporangium they were more likely to produce gametophytes, whereas, after an extended swarm period they frequently formed sporophytes."

In addition to the irregularities noted above there is another: the occasional appearance of resistant sporangia on sexual plants. Hatch, 1934 (7), Emerson, 1937 (2), and Sörgel, 1937 (11), have all noted this phenomenon.

We know that the resistant sporangia on sexual mycelia observed by Hatch (8), were either subtended by male gametangia (which may also subtend female gametangia), or that these resistant sporangia were found on sympodial branches coming off below couplets of gametangia—which resistant sporangia either terminated the growth of the branch or later gave rise to whole chains of gametangia. We also know that zoöspores from these resistant sporangia gave rise to sexual plants (Hatch, 8). But this is about all that is known of these resistant sporangia.

Emerson has pointed out: "it should be noted that nothing definite is known concerning the adjustments in chromosome number which must necessarily occur in conjunction with the various departures from the regular life cycle in *Euallomyces*." It was our feeling that, while these adjustments may occur, the determining factors were largely physiological.

This feeling was not without experimental support. In 1938 Tupper,¹ working with *Allomyces arbusculus*, discovered that resistant sporangia from asexual plants grown on maltose-peptone agar gave rise to different products when introduced into a full-strength maltose-peptone solution than when they were inoculated into sterile snow water to which small bits of hemp seed had been added. The plants that developed from the zoöspores of the resistant sporangia cultured in the maltose-peptone solution were exclusively asexual, whereas those that developed from the zoöspores of resistant sporangia cultured in the sterile snow water were preponderantly sexual. In the sterile snow water cultures the only asexual plants observed were those that developed on the hemp seed itself. The resistant sporangia involved in these experiments were genetically similar and were dried for the same length of time (15 days) in small agar blocks cut out of the parent-culture. Under the conditions of this experiment nutrition certainly appeared important in determining the sexual-asexual nature of the products of resistant sporangia.

In other experiments conducted at this time the resistant sporangia were dried for longer periods, and it was noted that whereas the resistant sporangia that had been dried for but 15 days pro-

¹ Stewart Tupper, unpublished notes of work done with the senior author in the Department of Botany, Dartmouth College.

duced asexual plants in a maltose-peptone solution, resistant sporangia dried for longer periods gave rise to fewer and finally to no asexual plants in the same solution. From these experiments it appeared that the amount of drying experienced by resistant sporangia was another important factor in determining the sexual-asexual nature of the products of resistant sporangia.

TECHNIQUE

The source of material for these studies was air-dried asexual plants from water cultures of *Allomyces arbusculus*, North Carolina strain. This material, dried since October 5, 1939, was recultured on hemp seed in sterile distilled water December 22, 1942. The asexual plant was brought into pure culture by inoculating maltose-peptone agar plates with single hyphae and by subculturing when freed of contaminants.

To obtain resistant sporangia whose number would always be approximately equal in each bit of inoculum, whose ages were known even to the day, and whose genetic constitution was the same, the following procedure was devised:

Asexual plants were started on fresh maltose-peptone agar plates. On the bottom of these plates several radially-arranged strips of gummed paper were affixed. By marking the extent of each day's growth on these strips, the daily growth of the fungus could be recorded. Growth rings, as was to be expected, appeared in these cultures. These rings, which have been observed by all workers with the fungus and which have been ascribed to diurnal temperature fluctuations by Hatch (6), were observed to follow a daily rhythm. But these growth rings were not always sharp and distinct because the diurnal fluctuations were not always sharp, and so it was found very helpful to have this additional record of the growth of the fungus. When the fungus had grown out towards the edge of the Petri dish, small agar discs were cut from each growth ring. These discs were cut by means of a wire loop of the type commonly used for bacteriological transfers. This loop was bent at right angles to the handle and cuttings were made by simply forcing the loop into the agar. Such a loop may be bent to cut discs of any desired size; those in this work were

approximately 1.5 mm. in diameter. The discs were allowed to air-dry on sterile slides in sterile Petri dishes.

PRELIMINARY EXPERIMENTATION

In preliminary experimentation designed to perfect technique, it was discovered that resistant sporangia which had attained an age of less than four days were incapable of throwing viable zoöspores. This, incidentally, was true for the resistant sporangia that were left undried, as well as those that were subsequently dried. This being the case, the youngest resistant sporangia used in our experiments were four days old; the oldest, eleven days old. This gave us a series in which the resistant sporangia were of eight different ages.

Although three-day-old resistant sporangia did not throw viable zoöspores during the progress of our experiments, it was determined that they were uncollapsed and possessed thick walls. Their contents, however, were generally coagulated in larger or smaller spherical masses, and in general the color of their walls was darker or a blacker brown than was the case in older resistant sporangia. It was further noted that in any growth ring the resistant sporangia were more numerous in the flush of reproductive activity and that the zoösporangia conversely were more numerous in the zone of light reproductive activity or on the threshold of this zone.

In these preliminary experiments it was also discovered that in agar discs dried for 48 hours, the thin-walled zoösporangia and the hyphae showed definite signs of collapse, and of incipient disintegration, and when tested in culture, it was established that all asexual material was non-viable. This is in agreement with Knip's (10) observation that in agar cultures, dried from one to three days, only the zoöspores of the resistant sporangia remain viable. To be absolutely certain of our methods the inoculum was dried for six days before making the first test. We have every confidence, therefore, that plants resulting from this inoculum were all products of zoöspores from resistant sporangia.

Preliminary experimentation also helped to establish the fact that swarming occurred from twelve to twenty plus hours after the inoculum was introduced into the cultures. It was further deter-

Concentration Maltose 1Peptone	Age attained by Resistant Sporangia before being dried (in days)										Ave. % Sex.	Length of Drying Period
	4	5	6	7	8	9	10	11	12			
Full Strength	8	9	10	14	11	10	11	12		10.6	6 Days	
1/25 Dilution	95	100	100	100	100	99	98	100		99		
1/50 Dilution	100	100	100	100	100	100	100	100		100		
Full Strength		27		32		30				29.7	12 Days	
1/25 Dilution		100		100		100				100		
1/50 Dilution		100		100		100				100		
Full Strength	65	66	69	67	70	66	64	66		66.7	18 Days	
1/25 Dilution	100	100	100	100	100	100	100	100		100		
1/50 Dilution	100	100	100	100	100	100	100	100		100		
Full Strength		100		100		100				100	24 Days	
1/25 Dilution		100		100		100				100		
1/50 Dilution		100		100		100				100		
Full Strength	100	100	100	100	100	100	100	100		100	30 Days	
1/25 Dilution	100	100	100	100	100	100	100	100		100		
1/50 Dilution	100	100	100	100	100	100	100	100		100		

TABLE I. Percentage of sexual plants derived from resistant sporangia dried for 6, 12, 18, 24 and 30 days, and subsequently committed to a maltose-peptone solution and to 1/25 and 1/50 dilutions of the same solution.

mined that the plants derived from swarming R.S. zoöspores did not form their reproductive structures before the 36th hour after inoculation and did not discharge their products before the 38th hour. The first plants of the second generation, *i.e.*, the plants derived from zygotes, if the first generation was sexual, or from

zoöspores, if the first generation was asexual, could not at the very earliest begin to germinate before 38 hours after inoculation. It was further determined that this second generation material could not grow to the point where it produced reproductive structure until 54 hours after inoculation. With these facts at hand, it was possible to develop a schedule which made certain that no second generation plants were included in observations upon, or counts of, first generation material.

The inoculum was removed from all dishes 12 to 20 hours after inoculation so no additional zoöspores could be discharged. At this time one cc. of solution with its swarmers was transferred from the 50 mm. Petri dish in which the swarming occurred to a 100 mm. Petri dish containing 19 cc. of the same medium. By the use of this dilution technique it was possible to make more accurate counts. These counts were always made before more than 50 hours had elapsed. Thus, there could be no doubt that whether the plants were sexual or asexual they were certainly derived from zoöspores from resistant sporangia.

In earlier experiments dealing with different concentrations of media, a maltose-peptone solution was used as the rich nutrient and distilled water with minute bits of hemp seed as the weak nutrient. Since the hemp seed medium was not a simple dilution, and since one could not be sure of precisely what the hemp seed contributed, it was decided to try different dilutions of a maltose-peptone solution. It was also found that plants would develop rather well and produce good reproductive structures in these dilutions.

Contamination of our cultures proved to be a problem only in the case of the full-strength maltose-peptone solution, but even here it was found that it could be avoided by showing great care in the handling of the inoculum, in the inoculation itself, and in the subsequent transfer of swarmers. This preliminary experimentation also showed that contamination could be controlled by the omission of peptone from the media or by the treatment of the dried inoculum with 95 per cent alcohol for thirty seconds prior to the inoculation. Although these techniques did not seem to affect the number or the quality of the products of resistant sporangia, it was thought best not to use them because they might introduce

variables. In actual practice it was found unnecessary to use these precautions if care was taken in the handling of the cultures.

EXPERIMENTATION

To determine the effect, if any, of the drying of resistant sporangia upon the sexual-asexual ratio of their products, material from four to eleven days of age was dried for six days, twelve days, eighteen days, twenty-four days and thirty days, and subsequently committed to culture. To determine whether the nutrient in the cultures in which the resistant sporangia dehisced, the zoöspores swarmed, and the germling grew, had any effect on the sexual-asexual ratio of the resultant plants, resistant sporangia were inoculated into a full strength maltose-peptone solution and into two dilutions: a $\frac{1}{25}$ dilution and a $\frac{1}{50}$ dilution.

The actual experimental procedure consisted of setting up three different culture series, one series for the full-strength maltose-peptone solution and one for each dilution. Each series was made up of eight 50 mm. Petri dishes. Resistant sporangia of eight different ages, ranging from four through eleven days, were inoculated into each of these three series.

The most accurate method for detecting swarming was found to be examination under a compound microscope equipped with a dark field. This method was quick and certain. A magnification of 100 times was found highly satisfactory for this work.

As soon as swarming was noted, a single cc. of medium, together with its swarmers, was transferred from the 50 mm. Petri dishes to 19 cc. of a similar medium in a 100 mm. Petri dish. This was done in each instance with a sterile pipette. This dilution method enabled more accurate counting and examination of developing germlings.

As has been indicated already, the first reproductive structures began to develop on the young plants in about 36 hours, but characteristic pigmentation of the male gametangium, the best single character for the certain identification of sexual plants, did not become distinct for some hours later, so the examination and counting of the plants was postponed until 45 to 50 hours after inoculation. At this time the plants were examined for the presence of either zoösporangia and/or resistant sporangia, on the one hand,

or gametangia, on the other. As has been intimated, the recognition of sexual and asexual plants presented no particular difficulty. The color of the male gametangium, along with the arrangement and shape of the gametangia, made the identification of the sexual plants a reasonably simple matter. The lack of color, the arrangement and shape of zoösporangia, and/or resistant sporangia made the recognition of asexual plants easy. The sexual-asexual ratio was determined by making counts of each type. Here the practice was to count all plants if there were less than 100. If there were more, only the first 100 were counted and these sums were then converted to percentage of sexual plants.

Concentration Maltose Peptone	Length of Drying Period of Resistant Sporangia				
	6 Days	12 Days	18 Days	24 Days	30 Days
Full Strength	10.6	29.7	66.7	100	100
1/25 Dilution	99	100	100	100	100
1/50 Dilution	100	100	100	100	100

TABLE II. Average percentage of sexual plants derived from resistant sporangia dried for 6, 12, 18, 24 and 30 days, and subsequently committed to a maltose-peptone solution and to 1/25 and 1/50 dilutions of the same solution.

The selection of plants, of course, was always at random. Since the swarmers were of approximately the same age, accurate counts were facilitated by the fairly simultaneous development of reproductive structures. The fact that the young plants dispersed themselves rather evenly over the bottom of the Petri dish made their separate consideration possible. The results of these counts are embodied in tables I and II.

DISCUSSION

From a study of tables I and II it is evident that while the resistant sporangia in each experiment varied in age as much as 8 days, there still was no consistent difference or trend in the sexual-

asexual ratio of their products. The age attained in culture before they were dried did not seem to be very important except as it figured in elapsed time. The significant trends are to be seen in the sexual-asexual nature of the plants derived from resistant sporangia that had dried 6 days as opposed to those that had dried 12, 18, 24 or 30 days.

If (tables I and II) we compare the data presented for resistant sporangia dried for 6 days with that of resistant sporangia dried for 12 days, it is apparent that the effect of the additional drying is to increase the proportion of sexual products. If we compare, in turn, the data of resistant sporangia dried for 12 days with that of resistant sporangia dried for 18 days, it becomes apparent that this same trend continues. If we compare the products of resistant sporangia dried for 18 days with those of resistant sporangia dried for 24 days, we find that all products of resistant sporangia dried for 24 days are sexual, irrespective of the nutrient in which they developed. Resistant sporangia dried for 30 days continued to demonstrate this completely sexual condition.

Under the conditions of the experiment all products of resistant sporangia became exclusively sexual somewhere between the 18th and 24th day of drying. The precise number of days is of no consequence, because it is apparent that the number will vary, with temperature, size of inoculum, etc. Furthermore, the threshold for material dried without the protection of agar may well be different.

That nutrition is also important in determining the sexual-asexual nature of the products of dried resistant sporangia is apparent from a comparison of the results bearing on the plants developed in the three different concentrations of maltose-peptone solution. In all instances where the medium exerts a demonstrable influence on the products of the resistant sporangia, the rich medium seems to throw the products in an asexual direction. Under the conditions of the experiment it is to be noted that plants derived from zoöspores of resistant sporangia are predominantly asexual in rich nutrient media when the resistant sporangia have been dried for 6 and 12 days and that a large proportion are still asexual when the resistant sporangia have been dried 18 days. Only when resistant sporangia have been dried 24 days or longer

is the rich medium unable to affect the sexual-asexual nature of their products. In general it seems that the drying of resistant sporangia works in opposition to rich conditions of nutrition upon the ultimate expression of the sexual-asexual nature of the products of resistant sporangia.

CONCLUSION

It now seems possible to conclude that physical phenomena (dehydration and hydration) and possibly physiological conditions (nutrition) are of critical importance in determining the sexual or asexual nature of plants derived from *R. S.* zoöspores.

It would also seem that if we accept Kniep's (10), Harder and Sörgel's (4), Sörgel's (11), and Emerson's (2) explanation that meiosis occurs regularly in the resistant sporangium, and if we exclude nuclear fusions during the swarming or germination of the *R. S.* zoöspores, a possibility, but one that we find highly improbable, then our experiments can only be interpreted as carrying the clear implication that if we have not found a means of inhibiting meiosis (by lack of drying or by rich nutrient) we have found a way of creating a haploid sporophyte.

Whether in a given bit of inoculum meiosis is general in each resistant sporangium, whether it occurs only in certain resistant sporangia, or whether it is inhibited in all resistant sporangia, clearly seems to depend upon the amount of drying the resistant sporangia experience, or it depends upon the nutrient of the media in which they undergo final maturation (zoösporogenesis) and dehiscence. We do not know, of course, anything about what is implied in "drying" or "rich nutrient."

These experiments finally suggest that the common practice of drying resistant sporangia for "several weeks" before introducing them into water or weak nutrient culture may be responsible for the fact that the products from resistant sporangia were predominantly sexual in our earlier work (Hatch 1933-38).

SUMMARY

Allomyces arbusculus, North Carolina strain, was brought into culture and was experimented upon in an effort to determine what

effect drying and nutrition might have on the sexual-asexual ratio of the products of its resistant sporangia.

Previously unreported methods of culture and examination are described.

Experimental results demonstrate that when resistant sporangia are air-dried for 24 days the products of these sporangia are exclusively sexual and this condition will remain unchanged even when the resistant sporangia are brought to dehiscence in rich nutrient. The products of resistant sporangia dried for 18 days are predominantly sexual, but not exclusively so when cultured in rich nutrient. The products of resistant sporangia dried 12 days will be predominantly asexual in rich nutrient and the products of resistant sporangia dried only 6 days will not only be predominantly asexual in rich nutrient, but will produce some asexual plants in weak nutrient.

It is concluded that drying and nutrition affect the sexual-asexual ratio of the products of resistant sporangia.

It is suggested that the common practice of drying resistant sporangia for several weeks before inoculating into water or weak nutrient cultures may have been largely responsible for the fact that the products of resistant sporangia have, heretofore, been reported as being preponderantly sexual.

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A SPECIES OF ARTHROBOTRYS THAT CAPTURES SPRINGTAILS

CHARLES DRECHSLER¹

(WITH 6 FIGURES)

Of the predaceous fungi, numbering about 61, that have been made known both with respect to the vegetative stage active in capture of animals, and with respect to at least one reproductive phase sufficiently distinctive to provide a basis for identification, 3 are recognized as preying mainly on rotifers, 5 as preying habitually on testaceous rhizopods, 24 as preying habitually on *Amoebae*, and 29 as preying habitually on nematodes. Although offering an obvious analogy with the insectivorous phanerogams, the fungi hitherto reported to subsist through capture of motile animals have in no instance been found specially adapted for preying on insects. Such adaptation might, indeed, seem hardly possible, since even the smallest of the more familiar insects appear rather large in comparison with organisms of truly microscopic dimensions. Nevertheless, a hyphomycete has recently been observed, which, though no more robust than the several nematode-capturing forms closely related to it, is unmistakably adapted to prey primarily on insects, and under natural conditions presumably is given wholly to a predaceous mode of life.

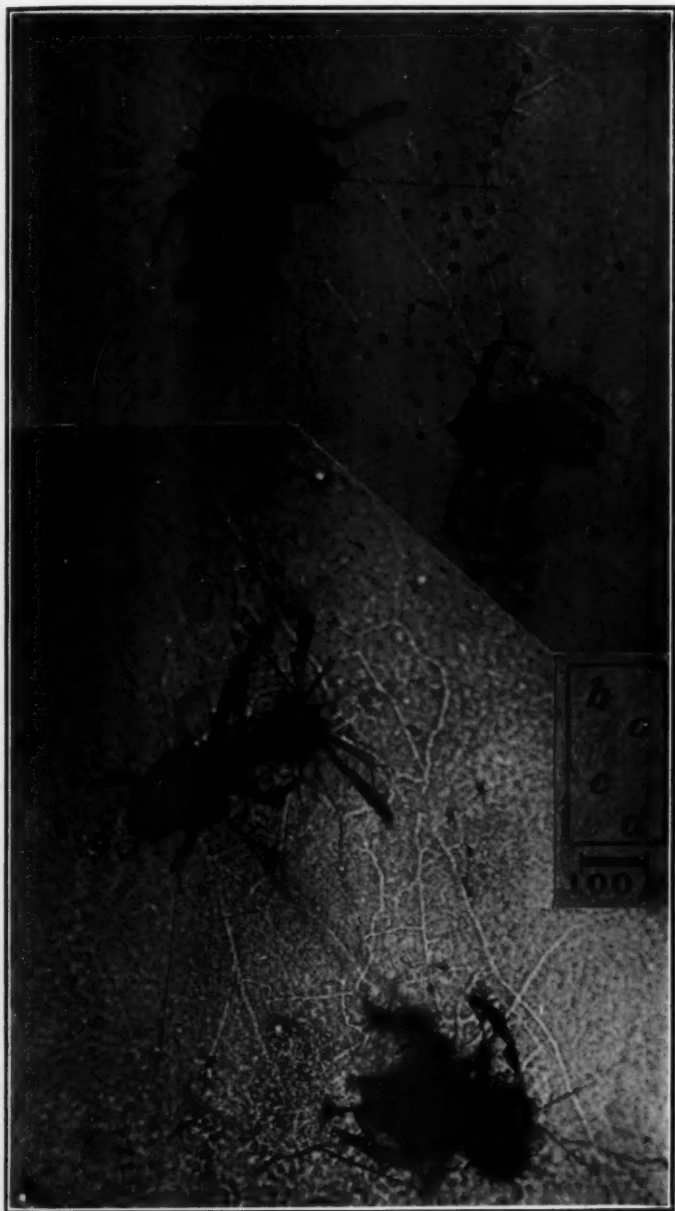
The hyphomycete in question made its appearance in 14 Petri plate cultures planted on Sept. 18, 1943, with discolored rootlets of *Polygonum pennsylvanicum* L. freshly collected from moist ground near a brook in Arlington, Va. Most of the cultures had previously been used in growing *Pythium ultimum* Trow and *P. vexans* de Bary, and thus were thoroughly permeated with oomycetous mycelium when the final planting was made. The few cultures

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wherein sterile medium—maizemeal agar of rather soft consistency—was used soon became permeated likewise with pythiaceous mycelium, as *P. palingenes* Drechsl. promptly grew out from each of the discolored rootlets. Development of bacteria in moderate quantity permitted gradual multiplication of rhizopods and eelworms, which, in turn, led to development of fungi subsisting on these animals. Examinations made at weekly intervals during the month of October revealed the 3 widespread nematode-capturing species *Arthrobotrys oligospora* Fres., *Dactylella ellipsospora* Grove, and *Dactylaria candida* (Nees) Sacc., variously intermixed with the 7 allied nematode-capturing forms I have described (2) under the binomials *A. conoides*, *A. musiformis*, *A. dactyloides*, *Dactylella bembicodes*, *Dactylella geophyropaga*, *Dactylaria brochopaga*, and *Dactylaria thaumasia*. Except that their conidiophores occasionally interfered with pedestrian locomotion, these fungi did not harmfully affect the concomitant development of a minute species of springtail often encountered on decaying plant materials that have been kept for some time under moist conditions. This springtail, whose length was usually found varying from 125 μ in small individuals to 350 μ in large individuals, and whose width was equivalent generally to one-third or two-fifths of its length, has been identified as a member of the genus *Sminthurides* (subgenus *Sphaeridia*) very similar to *Sminthurides* (*Sphaeridia*) *serratus* Folsom and Mills (6); it belongs, therefore, in the family Sminthuridae of the order Collembola.² If the earlier examinations gave no evidence that the insect was suffering any mishap, an examination made on November 1, when in most cultures it had attained numbers ranging from 50 to 100, showed many dead specimens grouped in small areas near the decaying roots added 44 days previously. A somewhat clustered arrangement of the dead insects and the constant proximity of many erect columnar processes (FIG. 1-4) indicated a predaceous fungus as the agent of destruction.

² For identification of this difficult insect, I am greatly indebted to Miss Grace Glance of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C. A general idea of its appearance may be gained from illustrations of related springtails given by Comstock (1: p. 229, fig. 236), by Folsom and Mills (6: figs. 19, 84), and by Mills (8: p. 123, fig. 13).

During the ensuing 10 days numerous additional groups of columnar processes appeared; the new groups being produced, for the most part, at increasingly greater distances from the root material whence the first groups had originated. This more widespread development was accomplished by radial extension of rather narrow, straightforward, hyaline, septate, prostrate hyphae that for relatively long distances showed only meager branching of commonplace character. However, at intervals these long hyphae would widen perceptibly and would give off several branches close together and at angles approaching a right angle. Not far from their respective origins, the branches, which in the beginning ran parallel with one another, would abruptly change their direction of growth to anastomose with one of their fellows, or would give off one or more secondary branches to accomplish a similar end; thereby forming a hyphal network prostrate on the surface of the substratum. Many of the segments composing the network then would send up, individually, an erect process consisting of a stout stalk-like basal cell together with a wider distal cell, ovoid or prolate ellipsoidal in shape (FIG. 5, *A*; *B*, *a-f*; *C*, *a-g*; FIG. 6, *A*, *a-p*). The distal cell, in all instances, soon secreted a relatively large quantity of a colorless adhesive liquid. In cultures well protected against evaporation for a few days, the adhesive liquid often appeared as a glistening globular droplet between 15 and 20 μ in diameter (FIG. 5, *A*, *a-m*); and it may be presumed that a guttular form is generally characteristic of the newly elaborated adhesive mass. However, more usually the body of adhesive exudate appeared as a rather strongly collapsed, irregularly lobate envelope surrounding the distal cell (FIG. 5, *A*, *n, o, s, t, v, x, z*; *B*, *a-f*; *C*, *a-g*; FIG. 6, *A*, *b, c, f, g, i, j, k, n, o, p*). When the columnar process was brought into a prostrate position, as frequently happened, the adhesive envelope would flatten out over the substratum and reveal a very thin peripheral film (FIG. 5, *A*, *n, p*; FIG. 6, *A*, *d, e, h, l, m*). Through secondary development a new erect process was often sent up from the base of a procumbent stalk (FIG. 5, *A*, *o, q*) or from a prostrate distal cell (FIG. 5, *A*, *u, v*); or a new adhesive process would arise not only from an older prostrate stalk but also from the glandular cell originally surmounting it (FIG. 5, *A*, *r, s, t*); or two new adhesive processes would arise from a

FIG. 1. *Arthrobotrys entomopaga*.

prostrate glandular cell (FIG. 5, *A*, *w*, *x*, *y*), one or the other, perchance, eventually in turn giving rise from its distal cell to an adhesive process of tertiary origin (FIG. 5, *A*, *z*).

The manner in which the erect processes operate as predaceous organs in the capture of springtails was immediately obvious from their general similarity to the intramatrix predaceous processes of *Dactylella ellipsozona* and of the two allied nematode-capturing hyphomycetes I have described as *Dactylella asthenopaga* (2) and *Dactylaria haptospora* (3).³ Borne aloft at a height usually of 10 to 15 μ the distal glandular cell is well placed for adhering to the ventral side of the low-bodied prey, or to its legs. The abundant elaboration of sticky exudate beforehand would seem important in assuring, at the very outset, such extensive adhesion that the effort of the insect to free itself by immediate use, more especially, of its powerful spring, will prove ineffectual. Owing to the close arrangement of the erect processes in groups, several of them probably often adhere to the animal at the same time, thereby fastening it down all the more securely.

Except for a frequently abnormal posture of body and appendages, which was obviously attributable to their struggles to escape, captured springtails for several days offered no marked departure in outward appearance when viewed under a microscope of low magnification; though closer examination at this time invariably showed the insects being permeated throughout with mycelium. Apparently, as in the 3 nematode-capturing hyphomycetes provided with similar predaceous organs, penetration is accomplished by the glandular cells most directly operative in effecting capture. Entrance of the fungus on the ventral side of prey was not brought under observation successfully. In instances where the fungus entered by way of an outstretched leg or sprawling antenna (FIG. 6, *B*, *a*) appearances indicated that the adhering glandular cell thrusts a narrow outgrowth through the thin integument, and then gives rise inside to a number of short swollen cells. From these swollen cells filamentous hyphae somewhat wider even than the hyphae

³ In view of their passive operation the predaceous organs here concerned invite comparison also with the stalked glands employed for capturing insects by 3 carnivorous phanerogamic plants (7), *Byblis linifolia* Salisb., *B. gigantea* Lindl., and *Drosophyllum lusitanicum* Lk.

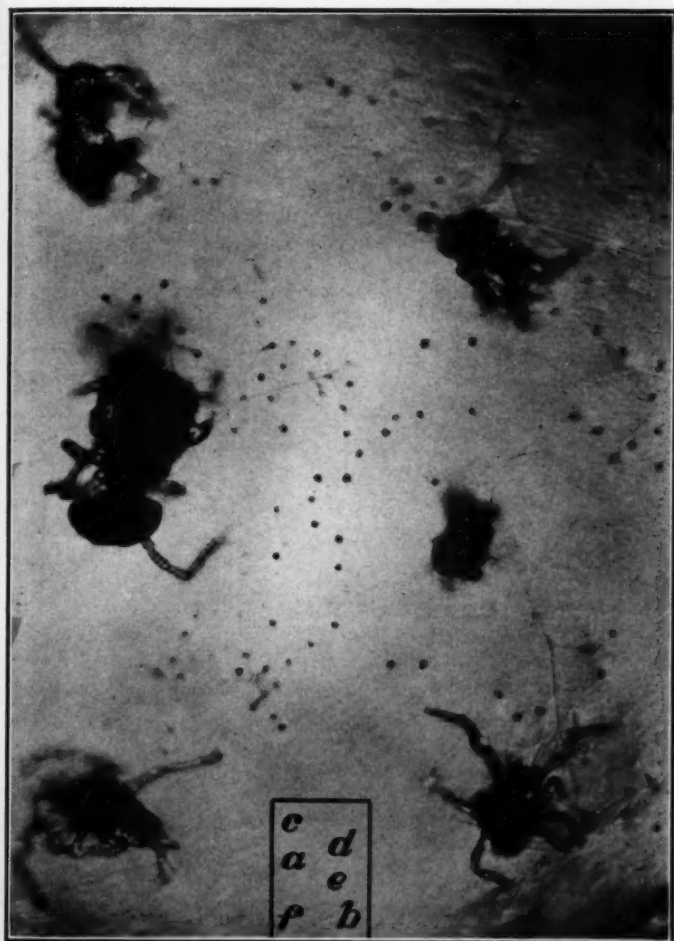


FIG. 2. *Arthrobotrys entomopaga*.

making up the prostrate network outside are extended to permeate the fleshy interior with a copiously ramifying assimilative mycelium. Rather marked irregularities in thickness of hyphae may appear at articulations between joints of the appendages (FIG. 6, *B, b; C*).

The assimilative hyphae are distinguished by greater width not only when they are found in captured springtails but also when they occur in nematodes. Invasion of nematodes came under observation with some frequency in several cultures in which mites had borne down many newly developed predaceous processes, thereby bringing numerous adhesive cells into prostrate positions where eelworms might readily brush against them. Division of the assimilative hyphae into rather short and often somewhat inflated segments gave the mycelium formed within invaded specimens of *Plectus parvus* Bastian, the species most frequently found serving as prey, a curiously knotted appearance (FIG. 5, *D*) not hitherto noted in any fungus habitually given to capture of eelworms. When assimilative mycelium developed within eelworms gave rise to predaceous apparatus, it produced erect columnar stalks (FIG. 5, *D, a-h*), each bearing aloft a glandular cell,—in fine, it produced apparatus primarily suitable for capturing springtails rather than for capturing nematodes.

Although in all hyphomycetes now known to prey habitually on nematodes the assimilative hyphae transfer their protoplasmic contents backward into the external mycelium by way of the channel of invasion, those of the present fungus were sometimes found erupting through the integument of an eelworm to extend new mycelial filaments externally without reference to the path of ingress (FIG. 5, *D*). Apparently eruption may likewise take place through the integument of a captured springtail, for not infrequently long aerial filaments were seen festooned from the dorsal surface of an immobilized insect like threads of a very scant cobweb (FIG. 1, *b, c, d*). However, as many captured springtails never showed any arachnoid development, there is reason to believe that the protoplasm elaborated by the fungus from the fleshy materials of its usual prey is for the most part withdrawn backward into the external mycelium. The elaborated protoplasm, in any case, makes possible continued growth of long filaments ex-

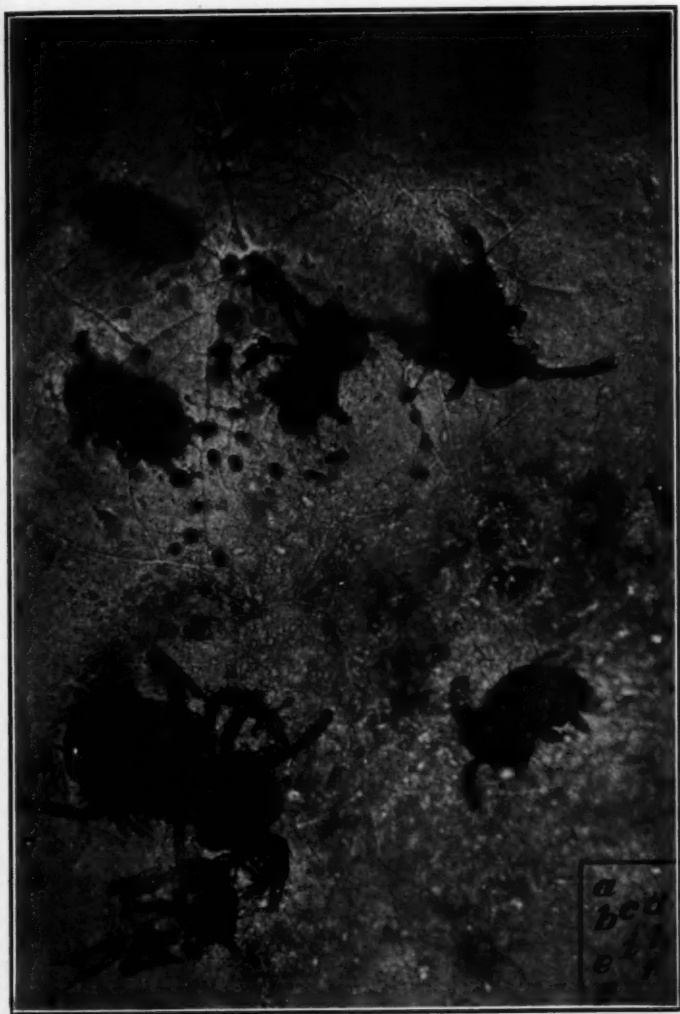
FIG. 3. *Arthrobotrys entomophaga*.

ternally and development on these filaments of additional groups of predaceous organs in the manner already described.

Indeed, in the cultures studied, almost all of the nourishment obtained from captured animals must have been expended in production of mycelial hyphae and predaceous organs—an expenditure

that might have been more profitable if the meager supply of available insects had not soon become exhausted. Only 3 of the 14 cultures showed any reproductive development, and in these 3 cultures only 10 conidiophores could be found, half of which were used in preparing drawings (FIG. 6, D-G). Owing to early evanescence of the long hyphal connections it was impossible in most instances to make out with certainty whether the conidiophores belonged to the same fungus as the clustered adhesive organs, though from the beginning both the conidial and the insect-capturing apparatus could be recognized as pertaining to some member of the predaceous series of hyphomycetes. In one instance, fortunately, hyphal anastomoses in proximity to membranous remains of several adhesive cells (FIG. 6, D, a-f) permitted easy recognition of the subjacent mycelium as consisting of an old insect-capturing hyphal network; a swollen living cell (FIG. 6, D, g) from which the solitary conidiophore arose being very clearly distinguishable as a glandular cell of the kind operative in capture of springtails.

The reproductive apparatus thus revealed in its proper connection did not conform at all closely to expectations suggested by the morphology of the predaceous parts. Among the nematode-capturing hyphomycetes now known, the closest approximation to the hyphal networks of the present fungus is found in the more or less scalariform networks of *Dactylella gephyropaga*, a species producing large pluriseptate conidia on robust conidiophores. Pluriseptate conidia are likewise produced by the 3 nematode-capturing species, already enumerated, whose predaceous organs show most resemblance to those employed in capture of springtails. Then, too, somewhat robust dimensions of reproductive parts might be inferred from the relatively large size of the prey; for though the species of springtail captured may be small in comparison with the more familiar types of insects, it is large in comparison with the rhizopods and eelworms habitually taken by other terricolous fungi of predaceous habit. Contrary to all presupposition founded on analogy, both the conidiophores and the regularly uniseptate conidia borne on them in clusters were of decidedly modest proportions,—the whole apparatus, indeed, having dimensions not greatly different from those of the congeneric form which I re-

FIG. 4. *Arthrobotrys entomopaga*.

cently described (5) as *Arthrobotrys cladodes* var. *macroides*, and which with respect to its aerial reproductive structures must be reckoned among the smallest of the nematode-capturing hyphomy-

cetes. As the conidia were attached on rather long sterigmata their arrangement in clusters resembled the loose capitate arrangement prevalent in *A. musiformis*, whose much sturdier conidiophore likewise is abruptly subramose at its tip. Resemblance to *A. musiformis* was especially manifest during early stages of development, when only a single conidial cluster was present (FIG. 6, E, a, x). In most of the 10 conidiophores that came under observation, production of the first conidial cluster had obviously been followed by renewed apical growth and repeated sporulation, since they bore aloft 2 (FIG. 6, D, h, y, z; E, b, y, z; F, a, b) or 3 (FIG. 6, G, a-c) spore clusters and thus offered marked contrast to the strictly monocephalous condition characteristic of *A. musiformis*. As this repeated production of conidia took place when sporulation was exceedingly scanty—so scanty that under comparable circumstances neither *A. superba* Corda nor *A. oligospora* nor *A. conoides* would ordinarily have formed more than a single cluster of spores—there is excellent reason to presume that the fungus has a very strong tendency toward repeated elongation of its conidiophores with concomitant development of conidial heads in prolonged succession. The merit of this presumption has not been confirmed so far by observations on pure cultures, as my attempts to isolate the fungus by aseptic transfer of conidia directly from the conidiophore to a sterile agar medium were all unsuccessful. Yet even without further knowledge of more prolonged development, the reproductive apparatus here discussed appears different from that of any species of *Arthrobotrys* hitherto made known. It seems appropriate, therefore, to present the insectivorous fungus as a new member of that genus, under a specific name compounded of two words meaning, respectively, "insect" and "trap."

***Arthrobotrys entomopaga* sp. nov.**

Mycelium effusum; hyphae steriles generis vulgaris longae, filiformes, incoloratae, mediocriter septatae, 2-3 μ crassae, saepe repentes et magna ex parte parvulum ramosae sed hic illic aliquantulum latescentes et ramos repentes 3-6 μ crassos crebre emittentes qui in rete coeunt et ramusculos tenaces erectos ferunt; ramusculis tenacibus vulgo bilocularibus, cellula inferiore cylindrata vel sursum attenuata, plerumque 7-17 μ longa, 2-5 μ crassa, cellula superiore quasi ovoidea, 8-13 μ longa, 4.5-8 μ crassa, involucro glutinis primum sphaerali mox collapsio circumdata, itaque ad insectum

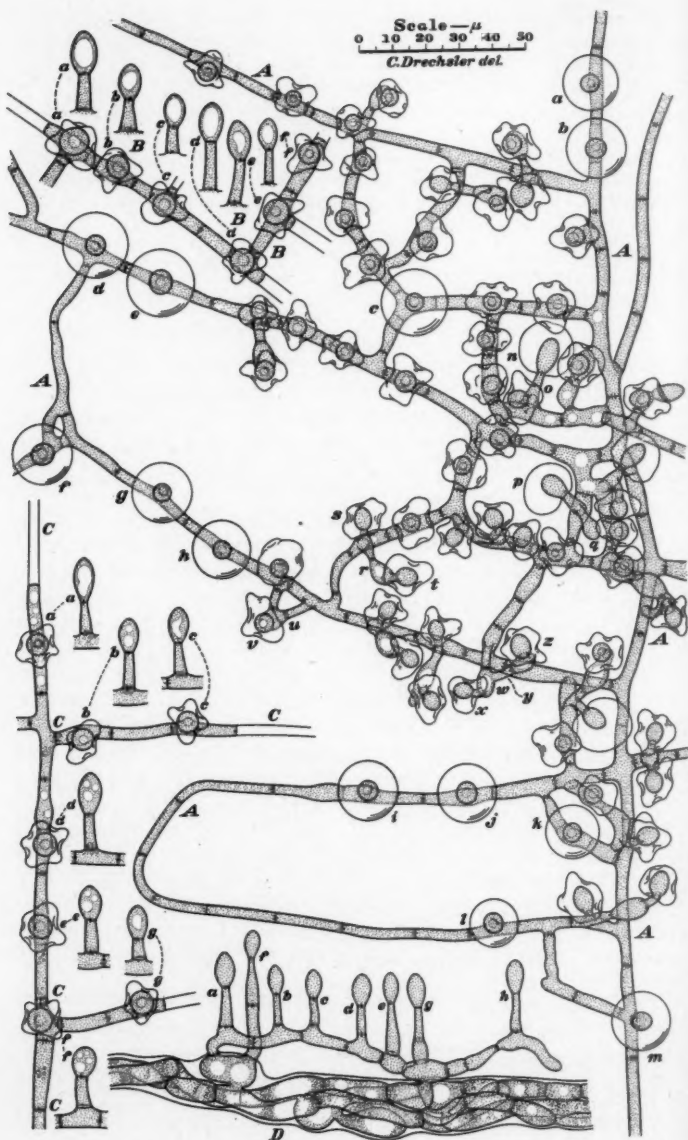
minutum inhaerente, hyphas ramosas $4-8\mu$ crassas in animal captivum intrudente quae carnem exhauriunt. Hyphae fertiles erectae, incoloratae, pauciseptatae, $75-175\mu$ altae, basi $3-4.5\mu$ crassae, sursum circa 2.5μ crassae, apice paulum inflatae, ibi $3-8$ sterigmatibus simplicibus vel furcatis $2-7\mu$ longis instructae, itaque $3-10$ conidia in capitulum laxum ferentes, denique identidem apice repullulantes alia capitula sporarum deinceps gerentes; conidiis hyalinis, cylindratis vel clavatis, apice rotundatis, basi vulgo aliquid attenuatis et minute pedicellatis, $15-28\mu$ longis, $4.5-5.5\mu$ crassis, uniseptatis, cellulis ferme quasi aequalibus tamen cellula inferiore saepe paulo longiore quam cellula superiore.

Insecta minuta specie *Sminthuridarum* (Collembola) etiam vermiculos nematodaeos praecipue *Plectum* parvum capiens consumensque habitat in radicibus putrescentibus *Polygoni pennsylvanici* in Arlington, Virginia.

Mycelium spreading; the ordinary vegetative hyphae long, filamentous, colorless, septate at moderate intervals, mostly $2-3\mu$ wide, often creeping on the surface of the substratum and over rather long distances only sparsely branched, but at intervals widening locally and from the widened portions giving off prostrate branches, mostly 3 to 6μ wide and spaced 10 to 40μ apart, which unite by anastomosis into a network and thereupon give rise to numerous erect aerial predaceous organs; these organs usually uniseptate, the lower cell stalk-like, cylindrical, or tapering upward, mostly 7 to 17μ long and 2 to 5μ wide, supporting aloft an ovoid or prolate ellipsoidal distal cell usually measuring 8 to 13μ in length by 4.5 to 8μ in width and soon becoming surrounded by an envelope of adhesive secretion effective in holding any suitable roaming springtail, which then is invaded throughout by branching assimilative hyphae 4 to 8μ wide. Conidiophores erect, colorless, meagerly septate, 75 to 175μ tall, 3 to 4.5μ wide at the base, about 2.5μ wide farther upward, often somewhat inflated at the top from which are given off 3 to 8 simple or branched sterigmata, 2 to 7μ long, whereon are borne collectively 3 to 10 conidia in loose capitate arrangement; additional conidial clusters often being produced following renewed axial elongation. Conidia colorless, cylindrical or somewhat clavate, 15 to 28μ long, 4.5 to 5.5μ wide, broadly rounded at the tip, often minutely pedicellate below, uniseptate, the 2 cells not pronouncedly unequal as a rule even though the lower cell is often slightly longer than the upper one.

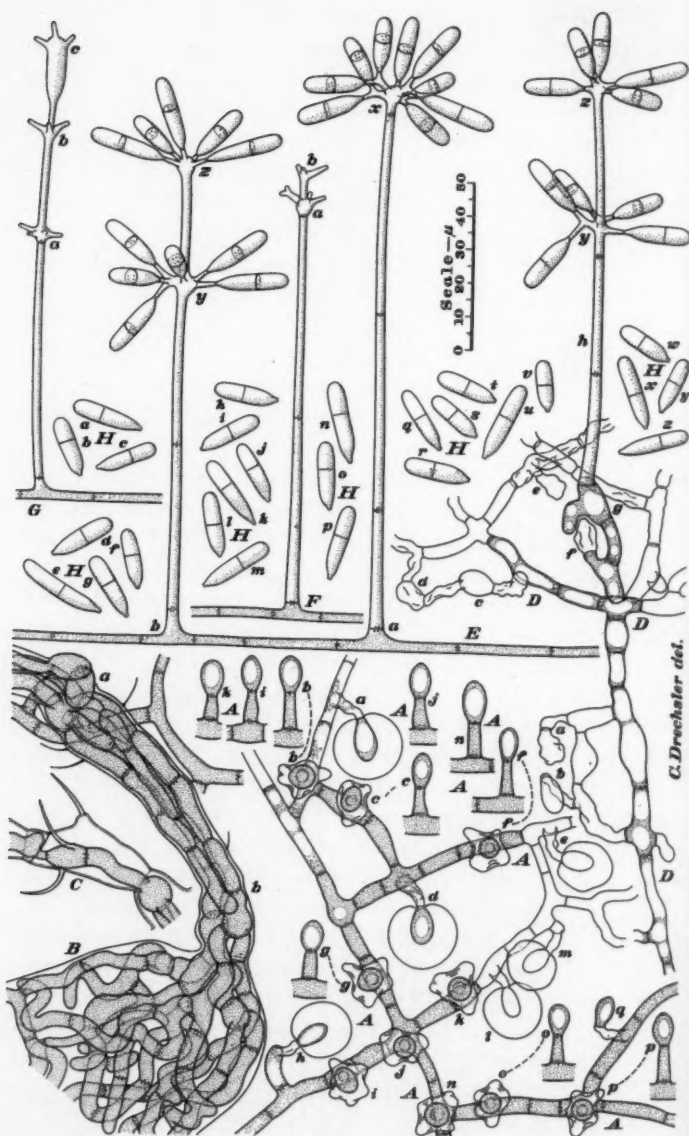
Capturing and consuming minute springtails referable to a species of *Sminthurides* very similar to *S. (Sphaeridia) serratus*, and occasionally also destroying various nematodes including *Plectus parvus*, it occurs in decaying roots of *Polygonum pennsylvanicum* in Arlington, Va.

The specific epithet in the new binomial is not intended to con-

FIG. 5. *Arthrobotrys entomopaga*.

vey the impression that *Arthrobotrys entomopaga* is considered to be probably the only fungus subsisting by capture of insects. On the contrary the close resemblance of the new species to familiar nematode-capturing forms gives reason to suspect that similar biotic adaptation may perhaps be uncovered in some of the various hyphomycetes which despite striking similarity and intimate relationship to species habitually preying on nematodes have under experimental conditions puzzlingly failed to capture eelworms or to form organs suitable for laying hold on minute animals of any kind (2: p. 538-540; 4: p. 349-360). In agar plate cultures planted with diseased rootlets or with leaf mold, these perplexing hyphomycetes ordinarily begin growing out of the vegetable detritus in much the same way as nematode-capturing forms, but, unlike the latter they cease developing after putting forth a scant display of conidiophores and conidia. Such discontinuance of growth might not unreasonably be expected in a predaceous fungus that after being introduced into a culture with some captured animals but without an escort of actively motile living prey, would need to conclude its production of mycelial hyphae and conidiophores as soon as the nutrient in the dead captives was exhausted. The different behavior of nematodes and springtails when material harboring them is used in planting agar cultures—the former little heeding the disturbance, the latter briskly springing away—would, from the start, tend to give the fungi predaceous on the two types of animals very unequal opportunity for visible extension into the transparent substratum. Later on, the slower hatching of springtail eggs as compared with nematode eggs, and the frequent failure of springtails to multiply well in agar cultures, must naturally operate to the further disadvantage of fungi subsisting on them. If adaptation for capture of insects may thus, perhaps, account in part for the meager development and unaggressive behavior of several fungi repeatedly tried out in the presence of nematodes and protozoans, it may, perhaps, likewise account for the fact that of the long-established hyphomycetous species manifestly belonging in the predaceous series only a small number have been recognized among the forms found preying on nematodes and protozoans.

At all events, the more minute of the terrestrial springtails ap-

FIG. 6. *Arthrobotrys entomopaga*.

pear well suited for extensive predaceous attack by mucedinous fungi. In their thoroughgoing infestation of decaying porous materials they roam the minute interstices and deeply ramifying passageways along which predaceous hyphomycetes can put forth adhesive organs under circumstances affording some protection against desiccation. The low position of their bodies relative to the floor on which they walk must facilitate ample contact with adhesive organs encountered by them. Their legs, though adequate for unobstructed walking, do not seem strong enough to overcome stubborn adhesion, nor are they attached in a manner favorable for effective traction. Once a minute springtail is securely held, its very thin integument could hardly be expected to offer much more resistance to hyphal penetration than is offered by the integument of a nematode.

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EXPLANATION OF FIGURES

FIG. 1. Predaceous mycelium of *Arthrobotrys entomopaga* with 4 captured springtails, *a-d*; one of the insects, *a*, seems little changed externally, having evidently been captured later than the 3 others, *b-d*, which not only look badly shrunken and collapsed, but offer a tousled appearance, owing to the several long aerial hyphae that extend for some distance above the substratum; the aerial hypha directed downward from insect *c* has given rise to the group of predaceous organs to the left of insect *d*. Unretouched photomicrographs taken with the microscope focussed on the surface of the substratum, and therefore showing the numerous adhesive bodies somewhat less distinctly than the underlying hyphal network; approximately $\times 100$.

FIG. 2. Predaceous mycelium of *Arthrobotrys entomopaga* with 6 captured springtails, *a-f*; 3 of the insects, *a-c*, seem little changed externally, having manifestly been captured later than the other 3, which appear badly collapsed. Unretouched photomicrographs taken with the microscope focussed about 15μ above the agar substratum, and therefore showing the numerous adhesive bodies more clearly than the underlying hyphal network; approximately $\times 100$.

FIG. 3. Predaceous mycelium of *Arthrobotrys entomopaga* with 6 captured springtails, *a-f*; 3 of the insects, *a-c*, seem little changed externally, having apparently been captured later than the other 3 noticeably collapsed ones, *d-f*. Unretouched photomicrograph taken with the microscope focussed about 20μ above the surface of the substratum, so that the adhesive bodies are shown more clearly than the underlying hyphal network; approximately $\times 100$.

FIG. 4. Predaceous mycelium of *Arthrobotrys entomopaga* with 7 captured springtails, *a-g*, in a somewhat collapsed condition; further, the disorganized remnants of 2 other captives, *h* and *i*, are faintly discernible within the same area. Unretouched photomicrograph taken with the microscope focussed on the surface of the substratum, and therefore showing the adhesive bodies less clearly than the underlying hyphal network; approximately $\times 100$.

FIG. 5. *Arthrobotrys entomopaga* as found developing in Petri plate cultures infested with springtails; drawn to a uniform magnification with the aid of a camera lucida; $\times 500$ throughout. *A*, Hyphal network with many predaceous organs, some of them, *a-m*, newly formed under good protection against evaporation, showing each distal cell surrounded by a glistening droplet of adhesive liquid; *n*, a prostrate predaceous organ whose adhesive envelope is flattened out on the moist substratum, and from whose stalk has been sent up a new predaceous organ, *o*; *p*, a prostrate predaceous organ from the stalk of which a new predaceous organ, *q*, is growing out; *r*, a prostrate predaceous organ that from its base has given rise to one new predaceous organ, *s*, and from its distal cell has given rise to another predaceous organ, *t*; *u*, a prostrate predaceous organ whose terminal cell has given rise to the new predaceous organ, *v*, and besides has anastomosed with its parent hypha; *w*, a prostrate predaceous organ whose terminal cell has put forth 2 new predaceous organs, *x* and *y*, whereof one, *y*, on coming into a prostrate position has given rise to another predaceous organ, *z*. *B*, Portion of hyphal network bearing 6 predaceous organs, *a-f*, shown as seen when viewed from above, in their normal erect posture, and also shown lengthwise (without adhesive secretion) as seen when viewed after being pressed down strongly under a cover-glass. *C*, Portion of hyphal network with 7 predaceous organs, *a-g*, shown not only as seen from above in their normal erect posture, but also shown lengthwise (without adhesive secretion) as seen when pressed down strongly under a cover-glass. *D*, Portion of nematode, *Plectus parvus*, occupied by mycelium of the fungus; from this mycelium branches have been pushed through the integument to give rise externally to 8 predaceous organs, *a-h*, which have not yet secreted any adhesive material.

FIG. 6. *Arthrobotrys entomopaga*, as found developing in Petri plate cultures infested with springtails; drawn to a uniform magnification with the

aid of a camera lucida; $\times 500$ throughout. *A*, Portion of hyphal network bearing 17 predaceous organs, *a-q*, among which seven—*a*, *d*, *e*, *h*, *l*, *m*, *q*—are in prostrate positions, with their envelopes of adhesive material flattened out on the substratum; the other organs, younger and still functional, being shown not only as seen when viewed from above in their normal erect posture, but also shown lengthwise (without adhesive secretion) as seen when pressed down strongly under a cover-glass. *B*, Portion of captured female springtail, showing part of its head and the two proximal segments of one antenna occupied by assimilative mycelium; *a*, region near articulation between second and third segments, where adhesive cell of a predaceous organ effected penetration of the antenna to initiate invasion of animal; *b*, articulation between first and second segments of antenna. *C*, Single assimilative filament in two proximal segments of an antenna of a male springtail. *D*, An old hyphal network with 6 empty collapsed adhesive cells, *a-f*, and a seventh adhesive cell, *g*, which, after coming into a prostrate position, has given rise to a conidiophore, *h*, bearing 2 conidial clusters, each containing 5 conidia. *E*, Portion of prostrate hypha from which have been sent up 2 conidiophores, *a* and *b*; the former bearing 9 conidia in a single cluster, *x*, the latter bearing 2 conidial clusters, *y* and *z*, containing 6 conidia and 5 conidia, respectively. *F*, Portion of prostrate hypha with a denuded conidiophore bearing 2 whorls of sterigmata, *a* and *b*. *G*, Portion of prostrate hypha with a denuded conidiophore bearing 3 whorls of sterigmata, *a-c*. *H*, Random assortment of conidia, *a-z*, showing variations in shape, size, and position of cross-wall.

NOTES ON THE USTILAGINALES OF THE THE WORLD IV^{1, 2}

GEORGE L. ZUNDEL

This paper reports proposed new species of smuts from various parts of the world and also new records of species already described. They all represent miscellaneous specimens sent to the writer during the compilation of a manuscript on the smuts of the world.

Ustilago Amphilophidis Zundel, sp. nov.

Sori destroying the ovaries, inconspicuous, less than 2 mm. long, concealed by the glumes, spore-mass dark brown, semi-powdery; spores globose to subglobose, sometimes angular, tinted olivaceous-brown, chiefly 8–10.5 μ diameter, smooth.

Soris ovaria perdentibus, inconspicuis, minus 2 mm. longis, glumis tegentibus, massa sporarum atro-brunnea, semi-pulverulenta; sporis globosis vel subglobosis, interdum angularibus, olivaceo-brunneis, plerumque 8–10.5 μ diam., levibus.

On *Amphilophis ischaemum* Nash, Pathankot, Gurdaspur Dist., India. Collected by R. R. Stewart, May 11, 1917. Gordon College Herbarium, Plants of the Punjab No. 1776. Elev. 1000 ft.

USTILAGO BURKILLII H. & P. Sydow.

On *Aneilema malabaricum* (L.) Merr., Tuguegarao, Cagayan Prov., Luzon, P. I. Coll. Dec. 29, 1923. Coll. Clemens No. 1741; Angat, Bulacan Prov., P. I. Coll. Clemens, Nov. 1924.

This species was abundant at Angeles, Pampanga Prov., Oct. 1923, Clemens.

¹ The willing coöperation of Dr. Robert E. Dengler, Professor of Classical Languages, The Pennsylvania State College, who wrote the Latin descriptions, is hereby gratefully acknowledged. Any errors are to be charged to the oversight of the author.

² Contribution from the Department of Botany, The Pennsylvania State College, No. 142, State College, Centre Co., Pa.

USTILAGO CYNODONTIS P. Henn.

On *Cynodon dactylon* (L.) Pers., Kigoma, Tanganyika Territory. Coll. Jan. 24, 1927. D. H. Linder, Flora of Tropical Africa No. 1953; coll. R. Thaxter, Oct. 1, 1905, Buenos Aires, Argentina.

USTILAGO ISACHNES Syd.

On *Isachne millacea* Roth., Sta. Maria, Bulacan Prov., Luzon, Nov. 1924. Coll. Clemens.

This is also abundant near Manila.

TRANZSCHELIELLA OTOPHORA LAVROV.

On *Stipa Lagascae* Roem. & Schult., Dayet Ahoua (Moyen-Atlas), Aug. 13, 1936. Champignons du Maroc 733 Ex. Herb. Crypt. G. Malencon.

Ustilago jehudana Zundel, sp. nov.

Sori destroying the anthers, spore-mass powdery, dark brown; spores globose to subglobose, regular, dark orange-brown, chiefly 10.5 to 14 μ diameter, reticulate.

Soris antheras perdentibus, massa sporartum pulverulenta, atro-brunnea; sporis globosis vel subglobosis, regularibus, atro-croceo-brunneis, plerumque 10.5-14 μ diam., reticulatis.

On *Silene apetala* Willd., Desert of Jehuda, Palestine. Coll. Dr. T. Rayss, March 25, 1935. Flora Cryptogamica Palestinae, Universitas Hebraica Hierosolymitana.

Ustilago belgiana Zundel, sp. nov.

Sori in the inflorescence, destroying the major part of the panicle from the base upward, dark-brown, powdery; spores globose to broadly ellipsoidal, regular, dark reddish-brown, chiefly 10.5-14 μ in diameter, abundantly but inconspicuously echinulate.

Soris in inflorescentia, majorem partem paniculi sursum a base perdentibus, atro-brunneis, pulverulentis; sporis globosis vel late ellipsoideis, regularibus, atro-rubro-brunneis, plerumque 10.5-14 μ diam., abundanter sed obscure echinulatis.

On *Digitaria horizontalis* Willd. and *Digitaria* sp., Kinshasa, Belgian Congo. Coll. D. H. Linder, Dec. 16, 1926, Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1614.

On *Digitaria Ischaemum* (Schreb.) Muhl., Sha Kan, Ch'ing Yang Hsien, Chiu Hua Shan, Prov. Ahnwei, China. Coll. S. Y. Chen, Oct. 24, 1932. Fungi of Ahnwei Province, China (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking), No. 1394 and No. 1393.

***Ustilago lycoperdiformis* Zundel, sp. nov.**

Sori transforming the ovaries and stamens into brown, irregular globoid, swollen bodies 3-5 mm. diameter, with a powdery, violaceous spore-mass, spores discharged through an ostiole or slit on the upper part of the globoid bodies; spores globose to elongated, irregular, hyaline-violaceous, chiefly 5-8 μ in length, thickly and minutely echinulate under high magnification.

Soris ovaria atque stamina in corpora brunnea, irregularia, globose tumefacta mutantibus, 3-5 mm. diam., massa sporarum pulverulenta, violacea, sporis per ostiolum vel rimam ex superiore parte corporum globosorum emissis; sporis globosis vel elongatis, irregularibus, hyalino-violaceis, plerumque 5-8 μ longis, dense et minute echinulatis sub olei immersione, ut dicunt, visis. Hujus speciei sori maxime notandi sunt quippe qui Lycoperda perparva in massis referant.

On *Polygonum* sp., Loh Hoh Tsuen, Ling Yuin Hsien, China. Coll. by S. Y. Chen, April 1, 1933. Fungi of Kwangsi province, China (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking), No. 1774.

The swollen sori of this species are very characteristic. *En masse* they resemble groups of miniature puff-balls.

***Ustilago morobiana* Zundel, sp. nov.**

Sori formed around the stem immediately below the floral parts, suppressing the development of the inflorescence, at first covered by a delicate membrane which flakes away revealing a dark, powdery spore-mass, entirely hidden by the enveloping leaf sheaths; spores globose to subglobose, occasionally cupped, reddish-brown, chiefly 3.5 to 6 μ diameter, smooth.

Soris circum caulem protinus sub partes florales consistentibus et inflorescentiae incrementum inhibentibus, membrana delicata in squamas dissipata atram pulverulentamque massam sporarum detegit, quam folia prorsus celant; sporis globosis vel subglobosis, interdum poculi formam praebentibus, rubro-brunneis, plerumque 3.5-6 μ diam., levibus. Haec species proxima est *Ustilagini Kusanoi* Syd. quam gigni in specie quadam *Miscanthi japonensis* referunt, sed differt eo quod tum sors dissimiles cum aliquantum majores et atriores sporas habet.

On *Miscanthus* sp., grassy hill, Boana, Morobe, New Guinea. Coll. M. S. Clemens, July 25, 1940.

This species is a very close relative to *Ustilago Kusanoi* Syd. described from Japan on *Miscanthus* species, but differs in having a different type of sorus, slightly larger and darker colored spores.

***Ustilago Stewartii* Zundel, sp. nov.**

Sori destroying the interior of the seeds, covered by the outer seed coat; spore-mass powdery dark-brown; spores globose to ovoid, chiefly regular, reddish-brown, chiefly $7-9\mu$ diameter, reticulate and coarsely winged.

Soris interiora seminum perdentibus, externo tegumine permanente; massa sporarum pulverulenta, atro-brunnea; sporis globosis vel ovoideis, plerumque regularibus, rubro-brunneis, plerumque $7-9\mu$ diam., reticulatis et crasse alatis.

On *Rheum Webbianum* Royle, Usi Mar, Deosai Plains, India. Coll. R. R. Stewart, Aug. 1, 1940. Plants of Kashmir, North-west Himalaya, elevation about 14,000 ft.

FARYSIA CARICIS-FILICINAE S. Ito.

On *Carex cruciata* Wahl., Loh Hoh Tsuen, Ling Yuin Hsien, Kwangsi Province, China. Coll. S. Y. Cheo, March 28, 1933. Fungi of Kwangsi Province, China, No. 1742.

FARYSIA MERRILLI (P. Henn.) Syd.

On *Carex Rafflesiana* Boot., Mt. Santo Tomas, Benguet, Luzon. Coll. Clemens, March 26, 1935. Flora of the Philippines No. 15810.

FARYSIA OLIVACEA (DC.) Syd.

On *Carex Rafflesiana* Boot. var. *scaberrima* (Boeck.) Kukenth., Mt. Santo Tomas, Benguet Prov., Luzon, P. I. Coll. Clemens, Feb. 19, 1925. Very common.

***Farysia ugandana* Zundel, sp. nov.**

Sori destroying scattered ovaries throughout the panicle, ovoid, 4-8 mm. diameter, powdery, fine elaters intermixed with the spore-mass; spores globose to subglobose, slightly irregular, rarely elongate, olivaceous-brown, chiefly 3.5 to 7μ in diameter, coarsely verruculate.

Soris ovaria per paniculum dispersa perdentibus, ovoideis, $4-8\mu$ diam., pulverulentis, elateribus tenuibus per massam sporarum intermixtis; sporis

globosis vel subglobosis, parum irregularibus, raro elongatis, olivaceo-brunneis, plerumque $3.5-7\ \mu$ diam., crasse verruculatis.

On *Carex paniculata-spicata* B. B. Clarke, between Kinanira and Kisola, Uganda. Coll. D. H. Linder, April 3, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), unnumbered.

SPHACELOTHECA BOREALIS (Clint.) Schell.

On *Polygonum* sp., Harbin, Manchuria. Coll. P. H. Dorsett, June 17, 1925, No. 3319.

Sphacelotheca borealis (Clinton) Schell. var. *chinensis* Zundel, var. nov.

This variety differs from the species in having the spores more regular and with more numerous sterile cells which are globose to subglobose, often irregular or angled, $7-14\ \mu$ diameter.

Haec varietas a specie differt eo quod sporas magis regulares et plures cellas steriles habet. Hae cellae globosae vel subglobosae, saepe irregulares vel angulatae, $7-14\ \mu$ diam., reperiuntur.

On *Polygonum Hydropiper* L., T'ien T'ai Wan, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Cheo, Oct. 19, 1932. Fungi of Anhwei Province, China, No. 1314 (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking).

Sphacelotheca Caricis-Petitianae Zundel, sp. nov.

Sori in the ovaries, destroying them, enlarged, globoid, about 3 mm. long, covered with a thin brownish membrane enclosing an olivaceous-brown, powdery, spore-mass surrounding a simple columella; sterile cells abundant, either singly or in long chains, hyaline, consisting of two sizes, oblong about $3.5\ \mu$ wide or globoid to elongate, chiefly $7-14\ \mu$ in length; spores very irregular in size and shape, globose to elongated or elongated and somewhat curved, often angular, olivaceous-brown, abundantly echinulate.

Soris ovaria perdentibus, dilatatis, globoideis, ca. 3 mm. longis, membrana tenui et brunnea, massa sporarum olivaceo-brunnea, pulverulenta, simplicem columellam circumstante; cellis sterilibus abundantibus, singulis vel longe catenatis, hyalinis, duarum magnitudinum—aut oblongatis ca. $3.5\ \mu$ latis, aut globoideis vel oblongatis $7-14\ \mu$ longis; sporis perirregularibus et forma et magnitudine, globosis vel elongatis vel subcurvatis, saepe angularibus, olivaceo-brunneis, abundanter echinulatis. Quantum scimus, ex scriptis quae

in promptu sunt, credimus hanc esse primam sphacelothecam in carice repertam.

On *Carex Petitiana* A. Rich., Belgian Congo. Coll. by Dr. Bequaert. Flora of Tropical Africa (expedition of the Harvard Institute of Tropical Biology and Medicine), unnumbered, 1926-1927.

Apparently this is the first *Sphacelotheca* ever reported on a *Carex* according to available records.

SPHACELOTHECA CRUENTA (Kuhn) Potter.

On *Sorghum vulgare* Pers. (*Andropogon Sorghum* Brot.), Chenkung, Yunnan, China. Coll. K. T. King, Oct. 1939.

***Sphacelotheca Linderii* Zundel, sp. nov.**

Sori destroying the ovaries, globoid, about 2 mm. long, covered by a delicate membrane which flakes away revealing a dark-brown, semi-agglutinated spore-mass surrounding a well developed, simple, columella; sterile cells hyaline, about the same size and shape as the spores, often in groups; spores globose to subglobose, often irregular and angled, light reddish-brown, chiefly $4-7\ \mu$ in diameter, abundantly but indistinctly echinulate under high magnification.

Soris ovaria perdentibus, globosis, ca. 2 mm. longis, membrana delicata in squamas dissipata massam atro-brunneam, semi-agglutinatam sporarum detegit quae columellam bene maturatam simplicemque circumstant; cellis sterilibus hyalinis, ejusdem fere magnitudinis formaeque ac sporae, saepe aggregatis; sporis globosis vel subglobosis, saepe irregularibus angulatisque, sub-rubro-brunneis, plerumque $4-7\ \mu$ diam., abundanter sed obscure echinulatis etiam sub olei ut dicunt immersione visis.

On *Digitaria horizontalis* Willd., Belgian Congo. Coll. D. H. Linder, Dec. 2, 1936. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1611.

***Sphacelotheca mauritiana* Zundel, sp. nov.**

Sori destroying the stamens causing them to swell and twist, long linear, 0.5-1 cm. long, covered by a tough blackish-brown membrane which flakes away into sterile cells exposing a powdery spore-mass surrounding a brittle columella; sterile cells of two sizes, one globose, $3.5-5\ \mu$ in diameter, hyaline, single; the other globose to irregular, up to $10.5\ \mu$ in diameter, hyaline, singly, in pairs or in groups; spores globose to subglobose, somewhat irregular, bright olivaceous-brown, chiefly $5-7\ \mu$ in diameter, echinulate under oil immersion.

Soris stamina tumefacientibus et torquentibus, mox perdentibus, longis linearibusque, 0.5-1 cm. longis, dura et atro-brunnea membrana, quae in squamas cellarum sterilium dissipata pulverulentam massam sporarum detegit, fragili columella; cellis sterilibus duarum magnitudinum—aliis globosis 3.5-5 μ diam. hyalinis singularibus, aliis globosis vel irregularibus usque ad 10.5 μ diam. hyalinis singulis vel binis vel congregatis; sporis globosis vel subglobosis, aliquantum irregularibus, clare olivaceo-brunneis, plerumque 5.7 μ diam. echinulatis sub olei ut dicunt immersione visis.

On *Stenotaphrum secundatum* (Walt.) Kuntze, near Reduit, Mauritius (Dept of Agriculture, Div. Plant Pathology, Mauritius). Coll. E. F. S. Shepherd, about 1941.

***Sphacelotheca nankingensis* Zundel, sp. nov.**

Sori destroying the flowers, filling them with a dark purple sport-mass surrounding a simple columella; sterile cells globose to subglobose, hyaline, chiefly 7-9 μ diameter; spores globose to subglobose or rarely elongated, violaceous, chiefly 10.5 to 12 μ diameter, finely echinulate under high magnification, thin epispore.

Soris flores perdentibus, massa sporarum atro-purpurea simplicem columellam circumstante; cellulis sterilibus globosis vel subglobosis, hyalinis, plerumque 7-9 μ diam.; sporis globosis vel subglobosis vel infrequenter elongatis, violaceis, plerumque 10.5-12 μ diam.; minute echinulatis sub olei, ut dicunt, immersione visis; episporo tenui. Haec species proxima *Sphacelothecae Polygoni-serrulati* Maire, sed differt eo quod crassum episporum non habet et quod sporae parum minores sunt.

On *Polygonum chinense* L., Shiang Lu Shih, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Chen, Nov. 20, 1932. Fungi of Anhwei Province, China, No. 1327 (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking).

This species is nearest *Sphacelotheca Polygoni-serrulati* Maire but differs in not having a thick epispore and having slightly smaller spores.

SPHACELOTHECA PENNISETI-JAPONICI (P. Henn.) S. Ito.

On *Pennisetum alopecuroides* (L.) Spreng, T'ien T'ai Wan, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Cheo, Oct. 14, 1932. Fungi of Anhwei Province, China, No. 1245.

SPHACELOTHECA TONGLINENSIS (Tracy & Earle) Zundel.

On *Ischaemum ciliare* Retz., Bogar, Java. Coll. M. Raciborski, 1899. Det. W. Siemaszko. Ex-herb. W. Siemaszko.

Reported as *Sphacelotheca Raciborskii* sp. nov. in herb.

Sphacelotheca tropico-africana Zundel, sp. nov.

Sori destroying the inflorescence, globoid, about 5 mm. long, covered by a membrane which flakes away into sterile cells, revealing a dark purplish, semi-powdery spore-mass surrounding a well developed columella; sterile cells very numerous, resembling immature spores, thick walled, globose to subglobose, hyaline, 7-17 μ diameter; spores globose to subglobose or broadly ellipsoidal, regular, light violaceous, chiefly 10.5 to 14 μ diameter, granular, smooth, epispore thick, about 1.5 μ wide.

Soris inflorescentiam perdentibus, globosis, ca. 5 mm. longis, membrana dissipata in cellas steriles, massa sporarum atro-purpurea, semi-pulverulenta et satis grandem columellam circumstante; cellis sterilibus numerosissimis, formam sporarum immaturarum praebentibus, dense vallatis, globosis vel subglobosis, hyalinis, 7-17 μ diam.; sporis globosis vel subglobosis vel late ellipsoideis, regularibus, sub-violaceis, plerumque 10.5-14 μ diam.; granularibus, levibus, epispore crasso, ca. 1.5 μ lato.

On *Polygonum* sp., Kibati at the foot of Mount Ninagongo, Belgian Congo. Coll. D. H. Linder, Feb. 16, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine) No. 2182.

CINTRACTIA PERIBEBUYENSIS (Speg.) Sawada.

Syn. *Cintractia minor* (Clint.) H. S. Jackson.

On *Cyperus malaccensis* Lam., Aparri, Cagayan, Luzon Island, P. I. Coll. Clemens, No. 1752.

SOROSPORIUM ARUNDINELLAE Sydow.

On *Arundinella nepalensis*, Gilgandra, N.S.W., Australia. Collected 1928. No. 7.

Sorosporium glutinosum Zundel, sp. nov.

Sori destroying the inflorescence, at first enclosed by the sheath with only the upper part protruding, 4-9 cm. long, 0.5-1 mm. wide, covered by a yellowish membrane which flakes away exposing long shreds intermixed with the granular dark-brown spore-mass; spore-balls reddish brown, globose to subglobose, often irregular to angled, composed of 9 to 25 spores held together by a gelatinous fungus substance surrounding each spore, 42-73.5 μ long; spores subglobose to broadly ellipsoidal, somewhat irregular, dark reddish-brown, chiefly 14-17.5 μ in diameter, finely echinulate only on exposed surfaces, otherwise smooth.

Soris inflorescentiam perdentibus, vagina conditis et superiorem partem prominentibus, 4-9 cm. longis, 0.5-1 mm. latis, membrana flava, quae fracta

longas fibras cum granulati atque atro-brunnea massa sporarum commixtas detegit; massa sporarum rubro-brunnea, globosa vel subglobosa, saepe irregulari et angulata, sporas habente 9-25 singulas per materiam quandam fungosam et gelatinosam conglutinatas 42-73.5 μ longas; sporis subglobosis vel late ellipsoideis, aliquantum irregularibus, fusce rubro-brunneis, praecipue 14-17.5 μ diam., minute echinulatis in superficie exposita, aliter levibus.

On *Heteropogon contortus* (L.) Beauv., near Reduit, Mauritius (Dept. of Agriculture, Div. Plant Pathology, Mauritius, Exsicc. D/208).

SOROSPORIUM POLLINAE P. Magnus.

On *Andropogon distachys* L. (*Pollinia distachys* Spreng), Ki'u'at, Palestine. Coll. by Dr. T. Rayss, April 20, 1938. Flora Cryptogamica Palaestinae, Universitas Hebraica Hierosolymitana.

This seems to be the first report of this species since the original by Magnus.

SOROSPORIUM REILIANUM (Kuhn) McAlp.

On *Sorghum vulgare* Pers., Sze Nan Hsien, Kweichow Province, China. Coll. by S. T. Cheo, Oct. 27, 1931. Fungi of Kweichow Province, China, No. 340.

Sorosporium tanganyikeanum Zundel, sp. nov.

Sori destroying the inflorescence, partially concealed by the leaf sheath, long linear, 4-4.5 cm. long, covered by a yellowish membrane which flakes away revealing a powdery spore-mass with numerous fine, yellowish shreds intermixed with the spores; spore-balls ovoid to broadly ellipsoidal, many spored, opaque, dark brown, semi-permanent, chiefly 52 to 87.5 μ long; spores globose to subglobose, frequently irregular, light olivaceous-brown, chiefly 5-7 μ diameter, smooth.

Sori inflorescentiam perdentibus, in vagina folii partim celatis, longis, linearibus, 4-4.5 cm. longis, membrana subflava in squamas dissipata massam pulverulentam sporarum ostendit, frustis tenuibus et subflavis cum sporis copiose commixtis; globis sporarum ovoideis vel late ellipsoideis, sporis numerosis, opacis, atro-brunneis, semi-perpetuis, plerumque 52-87.5 μ longis; sporis globosis vel subglobosis, saepe irregularibus, clare olivaceo-brunneis, 5-7 μ diam., levibus.

On *Panicum repens* L., Kigoma, Tanganyika Territory, Africa. Coll. D. H. Linder, January 24, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1955.

Sorosporium terrareginalense Zundel, sp. nov.

Sori destroying the inflorescence, at first hidden by the glumes, long, cylindrical, about 1-1.5 cm. long, covered by a yellowish membrane which dehisces apically exposing a dark spore-mass, at first semi-agglutinated but later granular, powdery, intermixed with elators or shreds of host tissue, spore-balls dark, at first firm, later disintegrating, variable in shape and size, subglobose to angular, $50-110\mu$ in length; spores variable in shape, subglobose to elongated, chiefly angular, often irregular, dark olivaceous-brown, epispore concolorous, chiefly 10.5 to 17.5μ in length, smooth.

Soris inflorentiam perdentibus, primo celatis in glumis, longis cylindricis, ca. 1-1.5 cm. longis, flava membrana rupta et ad apicem dehiscens fuscam massam sporarum detegit, primo semi-agglutinatum, inde granularem pulverulentumque et elatoribus fibrisque hospitis intermixtum; massis sporarum fuscis firmisque, mox solutis varias formas magnitudinesque habentibus, subglobosis vel angularibus, $50-110\mu$ longis; sporis variformibus, subglobosis vel elongatis, praecipue angularibus, saepe irregularibus, fusce olivaceo-brunneis, episporo concolori, praecipue $10.5-17.5\mu$ longis, levibus.

On *Cymbopogon refractus* (R. Br.) A Camas, Highway near Mt. Coot-tha, Brisbane, Queensland, Australia. Coll. M. S. Clemens, Feb. 9, 1943. (No collection number.)

Sorosporium texanum Zundel, sp. nov.

Sori destroying the inflorescence, long linear, about 8 cm. or more long and 2 mm. wide, covered by a thick, pinkish-white membrane which shreds from the apex downward revealing a very hard compartment, stuffed, dark-brown spore-mass which soon disintegrated into a granular mass; spore-balls ovate to elongate, many-spored, opaque, semi-permanent, $52.5-105\mu \times 45-70\mu$; spores subglobose, often irregular and sometimes angled, light olivaceous-brown, chiefly $7-10.5\mu$ diameter, smooth.

Soris inflorescentiam perdentibus, longis, linearibus, ca. 8 cm. vel amplius longis, 2 mm. latis, membrana crassa et subpiceo-alba ab apice minutatim dissecta perduram compactamque massam atro-brunneam sporarum detegente, massa speciem granorum mox praebente. Globis sporarum ovatis vel elongatis, multisporibus, opacis, semi-permanentibus, $52.5-105\mu \times 45-70\mu$; sporis subglobosis, saepe irregularibus et interdum angulatis, clare olivaceo-brunneis, plerumque $7-10.5\mu$ diam., levibus. Quia specimen vile tantummodo aderat, haec species profundius investiganda erit.

On *Pennisetum nervosum* (Nees) Trin., Fort Brown, Brownsville, Texas. Coll. Hansel, Dec. 23, 1942. No. 52794. Comm. J. A. Stevenson.

This species requires more careful study since only a very poor specimen was available for study.

THECAPHORA HAUMANI Speg.

On *Iresine celosia* L., San German, Puerto Rico. Coll. Ismael Velez, June 6, 1943. Comm. Carlos E. Chardon. Det. G. L. Zundel.

MELANOPSICHIMUM AUSTRO-AMERICANUM (Speg.) Beck.

On *Polygonum minus* Huds., Baguio, Luzon, P. I., elev. 4-5000', wet grassy place. March 14, 1935.

? **TILLETIA AYRESII** Berk. (poor spec.)

On *Panicum maximum* Jacq., Bumba, Belgian Congo. Flora of Tropical Africa, 1817a. Coll. D. H. Linder, Dec. 29, 1926.

TILLETIA PENNISETINA Syd.

On *Pennisetum alopecuroides* (L.) Spreng, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. by S. Y. Cheo, October 15, 1932. Fungi of Anhwei Province, China, No. 1258.

On *Pennisetum compressum* R. Br. Coll. Oct. 10, 1925, by Yu Ta-fuh, waste land, Nanking, Kiangsu Province, China. Fungi of China, Herb. Univ. Nanking No. 741. Comm. R. H. Porter.

Tilletia Rhei Zundel, sp. nov.

Sori destroying the interior of the seeds, spore-mass agglutinated, semi-hard, somewhat intermixed with host tissue; spores globose to subglobose, chiefly regular, dark reddish-brown, chiefly 16-19 μ diameter, coarsely reticulate, coarsely winged around the edge of the spores; hyaline cells scattered throughout the spore-mass appearing as immature spores.

Soris interiora seminum perdentibus, massa sporarum agglutinata semidura, aliquantum cum materie hospitis intermixta; sporis globosis vel subglobosis, plerumque regularibus, atro-rubro-brunneis, plerumque 16-19 μ diam., crasse reticulatis, crasse alatis in margine sporarum; hyalinis cellis per massam sporarum velut sporis immaturis apparentibus.

In the seeds of *Rheum Franzsenbachii* Muent. (*R. undulatum* L.; *R. rhubarbarum* L.), Shansi: Chiao-Ch'eng, distr. Yün-ting-Shan, ad rupes in pratis alpinis ca. 2500 m.s.m., China. Coll. Harry Smith, Sept. 2, 1924. Mus. Botan. Stockholm No. 7451. Host. det. G. Samuelson 1928.

***Urocystis Colchici-lutei* Zundel, sp. nov.**

Sori as small elongated, ovoid pustules on the stem, about 1 mm. long, spore-mass powdery, rusty colored; spore-balls of various sizes and shapes, chiefly $20-50\ \mu$ in diameter, composed of one to three or rarely four fertile spores which are usually completely surrounded by the sterile cells, bright reddish-brown, usually concolorous; sterile cells thick walled, almost the same color as the spores; spores globose to subglobose, bright reddish-brown, chiefly 10.5 to $14\ \mu$ diameter, smooth.

Soris elongatis et ovoideis velutque pustulis in stirpe locatis, ca. 1 mm. longis, massa sporarum pulverulenta, robiginosa; globis sporarum forma et magnitudine diversis, praecipue $20-50\ \mu$ diam., ex una vel tribus vel raro quattuor sporis fertilibus compositis atque intra densos parietes cellarum sterilium plerumque contentis, clare rubro-brunneis, ferme concoloribus; sporis globosis vel subglobosis, clare rubro-brunneis, plerumque $10.5-14\ \mu$ diam., levibus. Haec species ab *Urocystide Colchici* differt eo quod sorum minorem, globam sporarum clariorem, sporas globarum numerosiores habet.

On *Colchicum luteum* Baker, Abbottabad, India. Coll. R. R. Stewart, April 15-18, 1935. Gordon College Herbarium, Plants of Hazara N. W. F. P., Northwest Himalaya No. 14616, elev. about 4200 ft.

This species differs from *Urocystis Colchici* by the smaller sorus, brighter colored spore-balls and more spores per spore-ball.

UROCYSTIS TRITICI Körn.

On *Triticum* sp. cult., Cauquenes, Chile. Coll. Sr. Juan Mandakovic, det. Sr. Sigurd Arentsen. Comm. Dept. de Sanidad Vegetal. Ministerio de Agricultura, Santiago.

***Entyloma wyomingense* Zundel, sp. nov.**

Sori as small brownish-white irregular spots 0.5 mm. or less to 2 mm. in diameter, most distinct on the upper side; spores very abundant, globose to subglobose, chiefly regular, light reddish-brown, chiefly $14-17.5\ \mu$ in diameter, smooth, thick epispore about $2\ \mu$ wide.

Soris maculis parvis, brunneo-albis et irregularibus, 0.5 mm. vel minus ad 2 mm. diam., in superiore superficie magis distinctis; sporis maxime abundantibus, globosis vel subglobosis, praecipue regularibus, clare rubro-brunneis, praecipue $14-17.5\ \mu$ diam., levibus, episporo crasso ca. $2\ \mu$ lato.

On *Delphinium Barbeyi* Huth., Medicine Bow Mountains, Wyoming. Coll. Aven Nelson, Aug. 10, 1914. The Rocky Mountain Herbarium No. 9678.

***Doassansia Rhinanthi* Lagh. sp. nov. in litt.**

Sori as small brown raised, globoid pustules on the stem, .25 to .5 mm. diameter, each containing one spore ball, often two or more pustules are fused; spore-balls dark brown, opaque, 300 to 350 μ diameter; outer cortical tissue consisting of a single layer of reddish-brown sterile cells, irregular, angular, chiefly 7-8 μ diameter; spores globose to subglobose, often irregular and angled, crowded, entirely filling the inner part of the spore-ball, hyaline, 10-12 μ diameter, smooth.

Soris parvis brunneis elevatis velut pustulis globosis in caule orientibus, .25-.5 mm. diam., globis sporarum singulis, frequenter duobus plusve pustulis fuis; globis atro-brunneis, opacis, 300-350 μ diam.; cortice externa ex singulis et sterilibus rubro-brunneisque cellis consistente, irregularibus, angularibus, plerumque 7-8 μ diam.; sporis globosis vel subglobosis, saepe irregularibus et angulatis, densis, interiorem partem sporarum globae prorsus replentibus, hyalinis, 10-12 μ diam., levibus. Hoc specimen in exsiccatis, quae apud herbarium Collegii Reipublicae Pennsylvaniae continentur, repertum est. Videtur numquam ante descriptum esse, vel saltem in litteris quae in promptu sunt nusquam apparet. Quamvis deterius sit specimen, versa *Doassansia* videtur, quapropter hanc descriptionem interdum praebuimus, dum materies melior et ad studium curatius aptior adsit. Garcke, in III. Flora Germaniae. hospitem nominat *Fistulariam Cristam galli* (L.) Wettstein; at ei, qui apud nos Scrophulariaceas maxime tractant, nomen generis *Rhinanthum* esse ducunt.

On *Rhinanthus minor* Ehrh., Wilmersdorfer, Wessen, Berlin, Germany, leg. P. Sydow, Nov. 22, 1895 (Sydow, Myc., March, 4306).

The specimen of this smut was found while going through the exsiccati in the Pennsylvania State College herbarium. Apparently there has been no published description, or at least none has been found in available literature. While the material is poor, it seems to be a good *Doassansia* and therefore the above description is tentatively given until better material is available for more careful and detailed study. Garcke in his III. Flora von Deutschland lists the host as *Fistularia Crista galli* (L.) Wettstein, but specialists on the Scrophulariaceae report that the genus name *Rhinanthus* is the valid name.

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APHANOMYCES AS A FISH PARASITE

LELAND SHANOR AND HERBERT B. SASLOW

(WITH 1 FIGURE)

During November, 1942, a serious outbreak of a fungal disease on fish developed in some of the aquaria in the Vivarium of the University of Illinois. The macroscopic appearance of the fungus on the infected fish suggested a water mold, possibly a delicate species of *Saprolegnia*, as the causal organism. Microscopical examination and cultural studies of the parasite revealed it to be a sterile *Aphanomyces*. Certain species of *Saprolegnia*, *Achlya*, and *Dictyuchus* are known to parasitize fish and in some instances to cause serious trouble. *Aphanomyces* species, however, are more widely known as plant parasites or as parasites of such Invertebrates as the European Crayfish and of some smaller fresh water *Crustacea*. Because of the severity of the epidemic here and its unusual occurrence as a parasite on fish,¹ we deem it of some interest to publish this brief account.

The first infection was noted in a small one gallon aquarium November 4th, 1942, and was observed in other aquaria within a few days. The fish in two small aquaria, those in a 28 gallon rectangular aquarium and those in a large concrete burial vault used as an aquarium, were almost entirely eliminated by this organism within a period of about two weeks. The source of inoculum is not known but it is probable that it was introduced along with some food materials grown in containers of fresh water kept outside of the Vivarium.

Adults as well as young were attacked in a characteristic manner and the virulence of the organism on both age groups was equally

¹ We have been unable to find any previous records of *Aphanomyces* occurring on fish. In this search of the literature we wish to acknowledge the help of Dr. D. H. Linder, who generously checked through the host index of the Farlow Reference Library for citations, and of Dr. W. N. Tiffney, who kindly looked through his personal file of references to fungal parasites of fish.

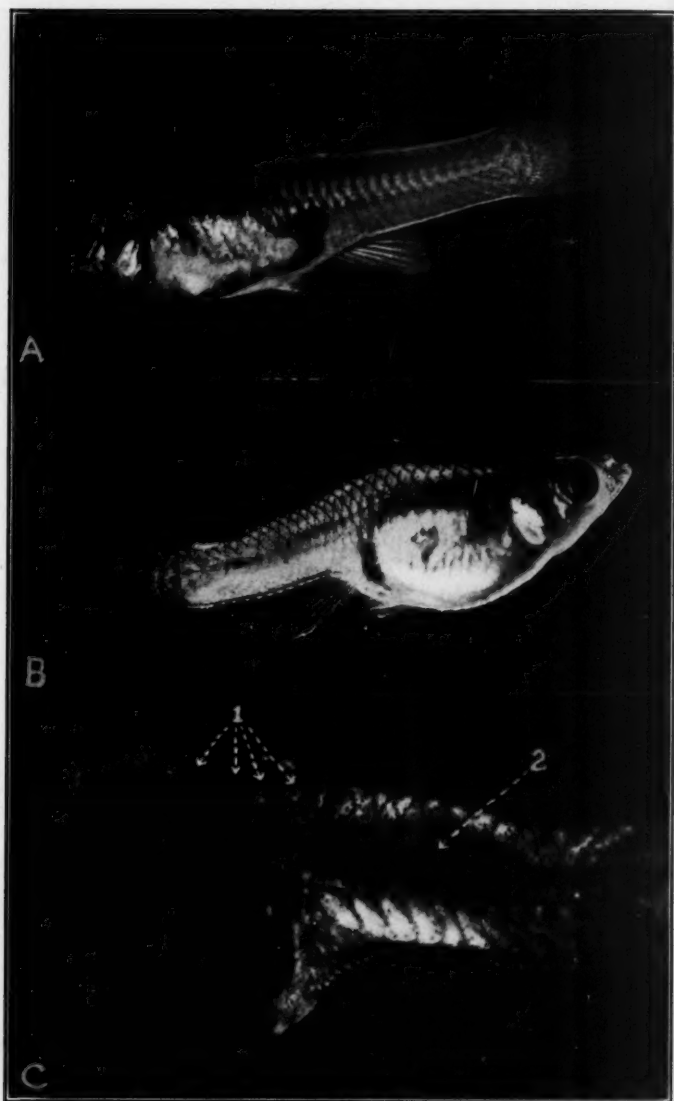


FIG. 1. *Lebistes reticulatus* Peters. A, normal young female; B, parasitized young female showing characteristic humped condition, an early symptom of the disease; C, central portion of the body enlarged to show mats of mycelium within dorsal musculature (1), and a lesion from which hyphae protrude (2). A and B about $\times 4.3$, C about $\times 10.4$. (Photographs by George Svihla.)

severe. The following fish were represented in the various infected aquaria: *Lebistes reticulatus* Peters (Guppy), *Anoptichthys jordani* Hubbs and Innes (Mexican Blind Cave Fish), and a hybrid of *Platypoecilus maculatus* Guenther (Platy) x *Xiphophorus helleri* Heckel (Swordtail). All of these seemed about equally susceptible to infection by this species of *Aphanomyces*.

The method of infection is not known. Previously acquired injury lesions or other evidence of any unhealthy condition were not detected in any of the specimens. The first evidence of *Aphanomyces* infection to be observed was a peculiar abnormal dorsal hump (FIG. 1, B). The parasite usually developed most extensively in the dorsal region (FIG. 1, C) and its activity in the musculature here seemed to be responsible for this peculiar spinal curvature. A few days later, the mycelium of the parasite was evident as whitish lumps within the distended musculature (FIG. 1, C.1). Soon after this first appearance of macroscopic symptoms of a diseased condition, the hyphae began to protrude from the lumps in tufts which extended out from the skin for a length of about 2 mm. Isolations were made of the external hyphae from these areas as well as from portions of the infected tissue, but only *Aphanomyces* was recovered. The *Aphanomyces* seemed to be the parasite entirely responsible for the condition and not an organism which had entered after the host tissue had been injured or when the vitality of the host had been lowered by some other primary type of infection. Usually within a week after lesions developed parasitized fish succumbed. None of the fish that became infected have recovered.

We have been unable to identify the species of *Aphanomyces* observed and isolated for sexual reproductive structures have not developed in any of the cultures and none have been observed in the infected tissue or on hyphae extending from lesions. It grows quite well on a number of culture media such as maltose-peptone agar, hempseed, grubs, etc. It is obviously a facultative parasite which may become destructive under suitable conditions.

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VOLUTELLA BUXI AND VERTICILLIUM BUXI

B. O. DODGE

The occurrence of a blight of dwarf English boxwood at East Hampton, L. I. was noted in a recent number of MYCOLOGIA (Dodge, 1944). Some of the blight was of the type usually referred to as wilt. Most of the leaves lost their chlorophyll and became thin or papery and very light straw-colored. Andrus (1933) and others have suggested that it may be a *Verticillium*, rather than winter killing, that brings on such a blight. One could see where in the East Hampton planting the owners had from time to time cut off other dead stems.

Both *Verticillium Buxi* and *Volutella Buxi* often developed when a branch bearing leaves infected with *Hyponectria Buxi* was placed in a damp chamber. It is a fact as stated by Dodge and Swift (1930), and easily verified, that cultures derived from conidia taken from sporodochia of *Volutella Buxi* in nature develop a *Verticillium* or *Acrostalagmus* phase preceding the formation of sporodochia. These authors did not realize, however, that the *Verticillium* that appeared in their cultures of *Volutella* might not be the true *Verticillium Buxi*. Further evidence is presented in this paper showing that *Volutella Buxi* and *Verticillium Buxi*, as Juel (1925) some years ago reported, are two very different species.

VERTICILLIUM BUXI

As a rule the sporophores are snow-white and evenly scattered over the under sides of the leaves. The conidia germinate slowly on a potato dextrose agar medium and the mycelial growth is also very slow. The mycelial mat is rather tough. The first aerial growth is composed of whitish, erect branches. Later growth is zonate, some zones being light pink to rose or peach colored. Old plate cultures are of a deep-rose color.

Small potted boxwood plants, kindly furnished by Drs. John M. Arthur and P. W. Zimmerman of Boyce Thompson Institute, were sprayed with spore suspensions and kept under bell jars in the laboratory for some time. It was nearly two weeks before certain new leaves became infected. Later on a number of the old leaves also became covered on the under side with the snow-white *Verticillium*. One of the four plants inoculated showed *Volutella Buxi* on a few leaves at the tip of a twig that must have been infected previously in nature. The other three plants inoculated developed only the *Verticillium*.

Leafy branches of different varieties of boxwood were then placed in large Petri-dishes, well moistened and autoclaved. The leaves were inoculated with a spore suspension. Within a few days all the leaves showed a fine growth of *Verticillium* on the under side, but no *Volutella* ever developed.

The spores of this *Verticillium* are broadly spindle-shaped and rather pointed at the ends. As they are formed one after another they adhere along their sides, being held together in long white chains, presenting the appearance of a white *Penicillium*. The conidia are apparently not easily dislodged or blown away by wind. When the dry tufts of conidiophores are placed in a drop of water the conidia are quickly dispersed with a jittery motion. It is only when very moist conditions prevail and growth is luxuriant that the conidia mass together and become slightly roseate. On potato dextrose agar in old cultures the conidial masses are deeply roseate. In this condition the culture presents somewhat the appearance of sporodochia of *Volutella* or of *Gliocladium*. Our infection experiments with living plants prove that this *Verticillium* is certainly not ordinarily a primary leaf blight. It is difficult to infect living leaves even under the abnormal conditions that prevail under bell jars.

VOLUTELLA BUXI

The feature that distinguishes a *Volutella* from other related genera is the presence of hairs or setae around the margin of the sporodochium. In nature as well as in culture many sporodochia of *Volutella Buxi* are wholly devoid of setae. The sporodochia may arise beneath the epidermis bursting out as whitish mounds

or pads of fungous growth which later becomes beautifully colored roseate or coral. The sporodochia are often developed on short stalks composed of compacted mycelial growths which have emerged through stomatal openings. The setae are rather short, coarse and have blunt ends. They arise from the base of the fruiting structure and grow up around the margin. A characteristic mark is the ruby-red drops of sticky substance at the tips of the hairs. This substance hardens on drying and may persist in herbarium specimens. It is readily dissolved in water so that in nature as well as in herbarium specimens the hairs may not be marked by the red beads.

The conidia of *Volutella Buxi* germinate quickly on potato dextrose agar. The mycelium grows about five times as fast as does that of *Verticillium Buxi*. The hyphae are also coarser. While the first growth is whitish, it becomes light pink or dull peach colored as the culture ages. In plate culture the growth is somewhat dappled or spotted and the mat is not at all leathery. Within two or three days sporulation begins. The conidia, in their shape and size, are similar to those of *Verticillium Buxi* but are more rounded or elliptical, and vary exceedingly in size. At first they are developed one by one at the ends of fairly long side branches of ascending or prostrate aerial hyphae which grow radially out from the point of inoculation. The fertile hyphae may grow along singly for some time but they often twist together in a sort of rope. As conidia develop they are held in a drop of clear watery substance so that the picture is sometimes much like that of a *Cephalosporium*. Cooke (1871) evidently mistook this stage for a *Mucor* which he thought was the perfect stage of *Penicillium roseum*. This point will be discussed later. Within a very few days one sees sporophores with verticillate branches, the ends of which are capped by drops of clear liquid containing many conidia, suggesting now an *Acrostalagmus*.

The next stage includes the massing together of a number of conidiophores as figured by Dodge and Swift (1930). From here on sporodochia of various types develop. Some of these bear coarse setae several cells in length, with rather rounded or blunt tip ends, usually capped with reddish drops.

Living boxwood plants were sprayed with a suspension of co-

nia and kept under bell jars. Within a week or so numerous leaves became infected. They were first covered on the under side with a white fluffy growth which later matted down on the leaf surface. Very soon large numbers of pink to coral colored sporodochia, with or without marginal hairs, were developed. None of the snow-white sporophores characteristic of *Verticillium Buxi* ever developed. Under moist conditions the sporodochia run together in a brightly colored sheet, showing few if any setae. Occasionally large sporodochia develop beneath the epidermis, then burst through as acervuli.

Volutella Buxi differs from *Verticillium Buxi* in several ways. In nature the conidia of the *Volutella* are pinkish roseate or coral color in mass. They are not as sharply pointed at the ends as are the conidia of the *Verticillium*. They also vary greatly in size. The sporophores of *Verticillium Buxi* are at first snow-white, seldom in nature acquiring a roseate or pinkish color. The conidia are broadly spindle-shaped, and adhere together by their sides in chains. On potato dextrose agar it is the *Verticillium* that develops the more beautiful roseate hues. Sterilized leaves of boxwood when inoculated with the *Volutella* develop the various forms which may include a *Cephalosporium* stage, a *Verticillium* or *Acrostalagmus* stage, and finally, a true sporodochial stage, with or without setae. When sterilized leaves are sprayed with a spore suspension of *Verticillium Buxi*, the under sides of the leaves become completely covered with a snow-white layer of verticillate sporophores. Under moist conditions, especially in old cultures, as noted previously, there is a massing of sporophores in the form of sporodochia which may be somewhat colored.

Heretofore many authors have assumed that the species variously identified as *Volutella Buxi* and *Verticillium Buxi* are merely two different types of fructification of one species. Others have taken the position that proof for such a connection has not been presented. After our culture work had proved clearly that there are two distinct species, a *Volutella* and a *Verticillium*, growing together, often on the same leaves of boxwood, a search of the literature on this point resulted in the finding of a paper by Juel (1925) which seems to have been overlooked by most of us. Juel did not use the single-spore culture method, but there can be no

question he was the first to prove that *Volutella Buxi* and *Verticillium Buxi* are two distinct species. Whether his conclusions as to their perfect or ascocarpic stages were well founded may be questioned. He agreed with previous authors that the perfect stage of the *Volutella* is *Nectriella Rousseliana* (Mont.) Sacc., because of the frequent association of these forms on the same leaves. He insisted, however, that there could be found in herbarium specimens as well as in nature, another, different and undescribed, species of *Nectriella* which he believed to be the perfect stage of *Verticillium Buxi*. He described this ascomycete as *Nectriella coronata* because of the corona of fine hairs which surround the ostiolar region. The writer has seen ascocarps of this type on leaves of herbarium specimens from Europe and also on one American specimen collected originally by Ravenel in South Carolina. Juel was unable to produce ascocarps of either species of *Nectriella* in his cultures on sterilized leaves or on prune agar. He did find in his cultures what he believed to be incipient ascocarps of the *Verticillium*. The writer has seen such structures on artificially infected leaves, but they did not develop far enough to prove anything. No such structures were seen on the sterilized leaves infected with the *Volutella*.

NECTRIELLA ROUSSELIANA VAR. VIRIDIS

Of great interest were some ascocarps which developed on twigs and leaves of boxwood from the East Hampton material. Both *Volutella Buxi* and *Verticillium Buxi* had developed on certain leaves and twigs in one damp chamber. Along with these structures there appeared some beautiful light chlorophyll-green fruiting bodies which were of about the size and shape of a *Nectriella*. As these bodies continued to enlarge they developed numbers of stiff hairs scattered over the surface. The perithecia were much like the one figured by Juel (1925) for *Nectriella Rousseliana*. The only difference was that on our specimens the hairs were always capped with bright ruby-red beads. These setae were like those found on sporodochia of *Volutella Buxi*, only they were more numerous in some cases, and thicker and stiffer. As the perithecia developed the chlorophyll-green color gradually deepened and finally changed to a black-green color, which later again changed

to amber brown. Practically all these ascocarps collapsed without ever showing any asci or spores which could be definitely determined as ascospores. Failure to develop asci may have been due to a chytrid (?) parasite which was present. This material showed that not all the ascocarps bore large numbers of stiff hairs. There were so many different stages in the development of the ascocarps represented that there could be no question that the beautiful green bodies mentioned were young perithecia, probably of *Nectriella Rousseliana*. Whether the ascocarps of this species are always green when young may be questioned.

The connection between this form and *Volutella Buxi* has not as yet been established by growing ascospores. The mere presence of the two forms, the *Volutella* and the *Nectriella* together on a leaf or twig, no matter how frequently, is, of course, no proof whatever of a connection. On the other hand the development of the same type of hairs on the sporodochia and on the perithecia, hairs that are in both cases ornamented with drops of ruby-red substance, certainly is better evidence of a connection. Both fruiting structures are haploid, having grown from haploid mycelia, in this case, both carrying the same genes for hair type. This would be but another example of similarities existing between the so-called sexual and asexual fruiting structures.

Berkeley and Broome (1859), under No. 898, described a new variety on boxwood leaves as *Nectria Rousseliana* var. *viridis*. "Peritheciis siccis atro-viridibus madidis prasiis ovalis pilis sparsis hyalinis obsitis; sporidiis ellipticis." They said that except as to the green color (leak colored when moist, blackish-green when dry) their plant resembled so closely that described by Montagne that they hesitated to make it a distinct species. No doubt what we at first thought was a discovery had, nearly a century previously, been made by Berkeley and Broome. They made no mention of the ruby colored beads on the ends of the hairs, however!

PENICILLIUM ROSEUM LINK AND PENICILLIUM
ROSEUM COOKE

Just what fungus from stems of *Solanum tuberosum* Link had before him when he described *Penicillium roseum* cannot be known with certainty. We are here concerned more with those fungi

found on leaves of boxwood and variously identified or distributed as *Penicillium roseum*, *Volutella Buxi*, *Verticillium Buxi* and otherwise. Dr. Charles Thom has pointed out to the writer personally that in his work, "Penicillia," under *Gliocladium roseum* (Link?) Bainier he referred to No. 1179 *Penicillium roseum* De Thümen Myc. Univ. on leaves of boxwood. Ravenel's material was evidently widely distributed. Our packet of No. 1179 represents mostly *Volutella Buxi* although some *Verticillium Buxi* is present. Ravenel's No. 571, Fungi Am. Exs. *Penicillium roseum* Link, contains three leaves which bear only *Volutella Buxi*, one leaf only *Verticillium Buxi*, and four leaves both species. The writer is indebted to Dr. Kenneth Raper for two cultures of *Gliocladium* from the Thom collection. Neither No. 1084, *G. roseum* nor No. 1752, *G. vermoeseni*, is now like any of the species of fungi we have seen on boxwood.

No. 1794 Sydow, Myc. March. "*Penicillium roseum* Link" has both *Volutella Buxi* and *Verticillium Buxi*. A packet "Ex herb. de Thümen, *Penicillium roseum* Link" and bearing what is said to be Ellis' number 2883 is a beautiful collection of *Volutella Buxi* with five leaves showing numbers of ascocarps of *Nectriella Rous-seliana*, bristling with coarse hairs some of which are still capped by the ruby-red droplets. The sporodochia of the *Volutella* present even after 77 years show similar hairs also with the reddish droplets at the ends. Here also the ascocarps are strongly collapsed.

No. 828, Ellis, N. Am. Fungi, "*Penicillium roseum* Link," is mostly *Verticillium Buxi* with some of the *Volutella*. Ellis' No. 810, "*Volutella Buxi*," is a mixture of the *Volutella* and the *Verticillium*. No 2593, Ellis & Ev. N. Am. Fungi, *Verticillium Buxi*, is all *Volutella Buxi*. Several packets collected by F. W. Anderson at Washington and distributed as *Verticillium Buxi*, represent mostly *Volutella Buxi*. The "*Penicillium roseum* Link?" reported and figured by Swift (1929) is neither our *Volutella* nor our *Verticillium*.

The real *Verticillium Buxi* certainly looks like a white *Penicillium*. No doubt under certain conditions the conidial masses become roseate. If *Volutella Buxi* in its various sporophore types, some pinkish or roseate, is represented on the same leaf with the

Verticillium, confusion must always exist. We are probably safe in concluding that when *Penicillium roseum* has been reported on boxwood, either *Verticillium Buxi* or *Volutella Buxi* (or both) was present. The *Penicillium* idea comes from the *Verticillium*, and "*roseum*" idea is primarily due to the *Volutella*.

MUCOR HYALINUS COOKE, AND PENICILLIUM ROSEUM
COOKE NOT LINK

Cooke (1871) under the title "Polymorphic fungi" writes as follows: "Some two or three years ago we collected a quantity of dead box-leaves on which grew a mould named by Link, *Penicillium roseum*. This mould has a roseate tint, and occurs in patches on the leaves; the threads are erect and branched above, bearing oblong, somewhat spindle-shaped, spores. When collected these leaves were examined and nothing was observed or noted upon them except *Penicillium*. After some time, incidently between two or three years, during which the [tin] box remained undisturbed, circumstances led to the examination again of one or two of the leaves, and afterwards a greater number of them, and patches of *Penicillium* were found to be intermixed with another mould of a higher development and of far different character (Pl. LXVIII. fig. 5). This mould, or rather *Mucor* for it belongs to the Mucorini, consists of erect branching threads, many of the branches terminating in a delicate globose head or sporangium, containing numerous very minute sub-globose sporidia. This species has been named *Mucor hyalinus*. The habit is very much like that of the *Penicillium*, but without any roseate tint. It is almost certain that the *Mucor* could not have been present when the *Penicillium* was examined, and the leaves on which it had grown were unloosened in the tin box, but that the *Mucor* afterwards appeared on the same leaves, sometimes from the same patches, and from the same mycelium. The great difference in the structure of the two species lies in the fructification. . . . We entertain no doubt whatever that the *Mucor*, to which we have alluded as grown on box-leaves intermixed with *Penicillium roseum*, is no other than the higher and more complete form of that species, and that the *Penicillium* is only its conidiiferous state."

In our herbarium there are two packets of Cooke's "Fungi Brit.

Exs. No. 359," co-type material. The under sides of the leaves are still covered with a *Cephalosporium*-like growth bearing in heads small elliptical spores of variable size. We do not find any definite remains of a roseate *Penicillium* on these leaves, but on one leaf there were several perithecia well marked with stiff hyaline hairs capped with ruby-red drops like those found on the leaves of typical *Volutella Buxi* and noted above as ornamenting our green perithecia of *Nectriella Rousseliana*. Cooke's perithecia were reddish, rusty, amber or fulvous-colored. Definite asci were not present although a few ascospores were seen in crushed mounts. Very likely No. 359 is merely the *Cephalosporium* stage of *Volutella Buxi*, and the ascocarps present on one leaf are those of the perfect stage. Cooke's *Penicillium roseum* was probably *Volutella Buxi* mixed in perhaps with *Verticillium Buxi*. In support of this statement we have in our herbarium No. 254, J. E. Vize, Micro-fungi Britannici, "*Mucor hyalinus*." Here the leaves are well covered with *Verticillium Buxi* and some *Hyponectria*. Furthermore, Vize's No. 339 "*Penicillium roseum* Link" in the same set, is practically all *Volutella Buxi*. Vize's No. 191, Brit. Fungi, labeled *Mucor hyalinus* is mostly, if not all, *Verticillium Buxi*.

Many attempts have been made to germinate spores taken directly from asci of *Hyponectria Buxi* without success. A number of spores taken at different times from the heaps of spores extruded from ascocarps and therefore presumed to be ascospores did germinate. Cultures from these spores gave good *Volutella Buxi*, which would indicate that the spores were not ascospores of the *Hyponectria*. It still remains to prove by single ascospore cultures the connection between *H. Buxi*, the *Nectriellas* and their imperfect stages. A beautiful roseate species of *Penicillium* has recently developed on twigs and leaves of boxwood held a long time in a damp chamber. This species is also being studied culturally.

SUMMARY

Culture experiments have proved that, as Juel first reported, *Volutella Buxi* and *Verticillium Buxi* are distinct species. Attention is called to a number of exsiccata specimens variously dis-

tributed as *Penicillium roseum*, *Volutella Buxi*, *Verticillium Buxi*, *Mucor hyalinus* and otherwise. It was pointed out that the stiff hairs or setae of *Volutella Buxi* are often capped with ruby-red beads which harden on drying. Hairs of the same type are often present on ascocarps of *Nectriella Rousseliana* and this is taken as better proof for a connection between the two forms than their mere presence on the same leaves.

The great variability in the size of the conidia of the *Volutella*, the presence and absence of hairs on sporodochia, the early development of conidia in drops of water suggesting *Cephalosporium* or *Acrostalagmus*, the different rates of growth of certain isolates, the great change of growth types in cultures derived from transplants from old cultures, are all questions calling for further study. Regardless of whether we may be dealing with different races or even species of what we have referred to in this paper as "*Volutella*" on boxwood, there can be no question that Juel was right in saying that *Verticillium Buxi* is an entirely distinct species.

THE NEW YORK BOTANICAL GARDEN.

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SACCARDO'S CONFUSION OF THE SPERMATIAL STAGE OF *S. DURIAEANA* AND *S. CURREYANA* WITH THE SPHACELIA STAGE OF *CLAVICEPS NIGRICANS*

H. H. WHETZEL

Tulasne (Ann. Sci. Nat. III 20: 51, pl. 4, fig. 15-22. 1853) described *Claviceps nigricans* occurring in the caryopsis of *Eleocharis* and *Scirpus*. He describes all three stages, spermatial, sclerotial and perithecial.

Saccardo, thirty years later (1880), having before him specimens later (1881) distributed in Roumeguere's Fungi Gallici 1200 on *Carex paniculata* bearing sclerotia in the culm with spermodochidia above, mistook the fungus to be the sphacelia stage of Tulasne's *Claviceps nigricans*. He applied the name "*Sphacelia nigricans* (Tul.)" Sacc. to the spermatial fruit-bodies and published a description of them (Michelia 2: 131. 1880). In the same publication (p. 134) he applied the name "*Sclerotium nigricans* (Tul.)" Sacc. to the sclerotial stage but gave no description, saying merely "in culms of *Carex paniculata*." In his description of *Sphacelia nigricans* and *Sclerotium nigricans*, he cites Therry as the collector. It seems obvious, however, that these two names were based upon the same specimen. The label on Roumeguere Fung. Gall. 1200 reads "*Sclerotium nigricans* (Tul.) Sacc. Michelia VI p. 134 *S. sulcatum* p. *Nigricans* Th. in litt." The "VI" is an error for II.

It is obvious from an examination of the Roumeguere specimen, that the fungus involved is the spermatial and sclerotial stages of Tulasne's *Sclerotinia duriaeana* as Whetzel (Mycologia 21: 9) has already pointed out.

In 1883 Saccardo (Syll. Fung. 2: 565) re-published the Latin description of *Claviceps nigricans* Tul. describing the perithecial stage and the sclerotium, but making no mention of the sphacelia

stage. He gives as hosts, *Eleocharis* and *Scirpus* and the range, France, Germany and Britain.

Six years after Saccardo's erroneous application of his name *Sphacelia nigricans* he compounded his original error by publishing (Syll. Fung. 4: 666. 1886) the new combination *Sphacelia ambiens* (Desm.) Sacc. He refers to his original publication "Mich. II, p. 131," and cites "*Epidocium ambiens* Desm. XXII, Not. p. 19" and "*Sphacelia nigricans* Sacc. olim" as synonyms. Remarking "*Sclerotio incipienti Clavicepitis nigricantes*," he presents a description of the sclerotium and the spermatial fruit-body, saying this fungus occurs on *Carex paniculata* and "aliarum in Gallia."

To further complicate matters, Saccardo in 1884 (Misc. Myc. In Venezia Inst. Atti 6: 2: 448) having before him a specimen of the spermatial stage of a fungus on the culms of *Juncus glaucus*, gave it the name *Sphacelia tenella* Sacc. and described it, the description appearing two years later (1886) in his Sylloge (4: 666) on the same page as his description of *Sphacelia ambiens* (Desm.) Sacc. The fungus on *Juncus glaucus* to which he applied this name is undoubtedly the spermatial stage of *Sclerotinia curreyana* (Berk. in Currey) Karst. He would seem, however, to have previously believed it to be his *Sphacelia nigricans* since he begins his description in Miscellanea Mycologia, "*Sphacelia nigricans* (Tul.) Sacc. S. *tenella* Sacc.," while in the Sylloge the name "*Sphacelia nigricans*" is discarded.

It is clear that he still labored under the delusion that the fungus in Roumeguere's 1200 was identical with Tulasne's *Claviceps nigricans*.

Nor does Saccardo appear to have ever discovered or at least acknowledged his error for finally in 1899, he published a description of his *Sclerotium nigricans* (Syll. Fung. 14: 1153) citing the original place of publication but dating it 1882 (erroneously for 1880)¹ saying that it is the mycelium "quiescens" of *Claviceps nigricans* Tul. and citing as a synonym "*Scl. Eleocharidis* Thüm. M. N. n. 2298 (1883)." This citation also is erroneous: it should read "Thüm. M. U. 2298 (1884)." Following the very brief de-

¹ Although the cover page of Michelia, vol. 2, bears the date 1882, the first 176 pages were issued in 1880 as is also stated on the cover page.

scription of the sclerotium, he gives as the habitat *Carex paniculata* and *Eleocharidis palustris* and for its distribution France and Denmark. Then, as if to emphasize his error, he adds the remark—"Est Sclerotium *Clavicipites nigricantis*."

It is clear then that the names *Sphacelia nigricans* (Tul.) Sacc. and *Sclerotium nigricans* (Tul.) Sacc. must be used for the respective stages of *Claviceps nigricans* Tul. regardless of the fact that Saccardo had in hand the spermatial and sclerotial stages of *Sclerotinia duriaeana* (Tul.) Rehm. The name *Sphacelia ambiens* (Desm.) Sacc. on the other hand is to be regarded as Saccardo's name for the spermatial stage of *Sclerotinia duriaeana* in spite of the obvious fact that he thought it identical with his *Sphacelia nigricans*, while *Sphacelia tenella* Sacc. is the spermatial stage of *Sclerotinia curreyana* (Berk. in Currey) Karst.

In placing these names in synonymy it would appear most proper to cite them as follows:

Claviceps nigricans Tul.

Sphacelia nigricans Sacc. Michelia 2: 131. 1880. specim. excl.

Sclerotium nigricans Sacc. Michelia 2: 134. 1880. specim. excl.

Sclerotinia duriaeana (Tul.) Rehm.

Sphacelia nigricans sensu Sacc. Michelia 2: 131. 1880.

Sclerotinia nigricans sensu Sacc. Michelia 2: 134. 1880.

Epidocium ambiens Sacc. Syll. Fung. 4: 666. 1886.

Sclerotinia curreyana (Berk. in Currey) Karst. Rev. Monogr. 123. 1885.

Sphacelia tenella Sacc. Syll. Fung. 4: 666. 1886. Sacc. Pro. Syn. Venezia Inst. Atti 6: 2: 448 (14). 1884.

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